Filler and Extender Minerals in Nova Scotia

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FILLER AND EXTENDER MINERALS IN NOVA SCOTIA

by

Peter Luke

ABSTRACT

A study of filler and extender minerals in Nova Scotia was initiated under the Mineral Development Agreement in the fall of 1986.

A regional market study concluded that filler minerals play an important role in Nova Scotia's economy and that some of the products used by such industries as paint producers and carpet manufacturers may be available in sufficient grade and quantity to be mined in Nova Scotia. Filler minerals are imported by Nova Scotia industries and transportation costs for these fillers are high so local consumers are very interested in an indigenous source.

The field study provided valuable information on some deposits with potential as fillers. Limestone from Glencoe and Marble Mountain, Inverness County, both tested extremely well. The Glencoe stone was ground and tested successfully as a paint filler at Tibbetts Paint Company, Trenton, Pictou County. A drilling program at Marble Mountain uncovered an even higher grade stone.

Other minerals investigated to some extent include kaolin, muscovite, barite, diatomite and silica.

This study has found that there are definite markets for local fillers and there are deposits in the Province that are acceptable grade to meet these market requirements.

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INTRODUCTION

Mineral fillers are generally inert, finely ground minerals that are incorporated into the manufacturing of various products. They reduce the consumption of more expensive raw materials such as plastic resin or rubber. Extenders enhance the final products usefulness by introducing new properties.

The use of finely ground minerals as fillers in manufactured products has developed from an experimental means of saving production cost to a $3 billion (U.S.) industry in North America alone.

Originally incorporated into products because of their inert behaviour, many different minerals are now being used, thanks to improving technologies, to enhance such properties as strength, flexibility and weight.

At least 15 minerals are considered to be major filler and extender products. These range in annual North American sales of from $2.3 million (U.S.) for nepheline syenite to $1.5 billion (U.S.) for the filler/pigment colouring titanium dioxide.

Annual figures for U.S. consumption of filler minerals by C. H. Kline and Associates show some dramatic increases over the years. Excluding the values for titanium dioxide, which is more a colourant than a filler, consumption has increased from $525 million (U.S.) in 1978 in North America to a forecast of $3.091 billion (U.S.) in 1991.

Fillers make up a very small percentage of sales by volume of industrial minerals, but a large percentage by dollar reflecting their worth per tonne (Table 1).

Table 1. General price range for high quality* filler minerals, 1985.

Filler	Median Particle Size Range	Specifications	Estimated Price Range (U.S. dollars)
Alumina hydrate	1.0-2.0 μm		600+
	7.0-10.0 μm		300-500
Barite	2.0-4.0 μm	bleached or natural	200-400
Ground calcium carbonate	1-2 μm		150-200
	4-6 μm		100
Diatomite	variable		175-750
Kaolin	0.5 μm	water washed	200-250
	soft	air floated	55- 90
	-2 μm	delaminated	150-300
	1-2 μm	calcined	275-500
		surface treated	250-750
Mica	95% passing 325 mesh	wet ground	400-500
	95% passing 325 mesh	dry ground	100-350
Ground silica	2 μm		200-350
	6-8 μm		75-100
Talc	2-4 μm	western	100-400
		eastern	175-250
Titanium dioxide	variable	anatase or rutile	0.80/lb
Wollastonite	95% passing 200 mesh		150-500

* low chemical impurities, high brightness values and finely ground product; figures after C. H. Kline and Associates, 1986

According to C. H. Kline and Associates' statistics for 1985, consumption of filler and extender minerals in North America was led by the paper industry at 46% of tonnage consumed with the other large consumers being adhesives and sealants, plastics, paint, rubber and carpet backing industries (Fig. 1). Other end uses for some of these industrial minerals include ceramics, animal feed and fertilizers.

Figure 2 shows the minerals that are used as fillers. Kaolin and calcium carbonate, because of their abundance, low cost, low abrasiveness and high brightness values are the two most popular fillers.

Kaolin's major application is as a filler and coater in paper but, like calcium carbonate, is very versatile and can be used in almost any industry. The calcium carbonate used in the industry is very high quality with few impurities and can be derived from deposits of limestone, dolomite, marble and calcite. Two specification sheets from the Pulverized Limestone Association (PLA) are included in Appendix 1. These state parameters which must be obtained to classify a calcium carbonate product into (a) a very fine ground high calcium limestone, and (b) a -325 mesh high calcium limestone according to their standards. Chemical, particle size and brightness values are some of the more important requirements to be met. Many of the high quality calcium carbonate filler producers are members of the PLA and these sheets can act as an excellent guide when assessing a limestone for its potential in the industry.

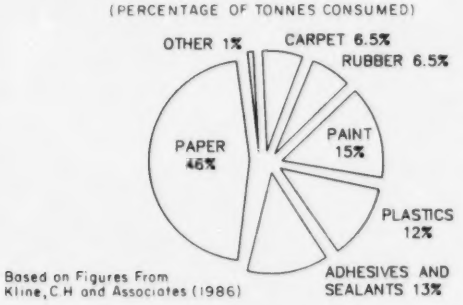


Figure 1. North American consumption of extender and filler minerals by market, 1985

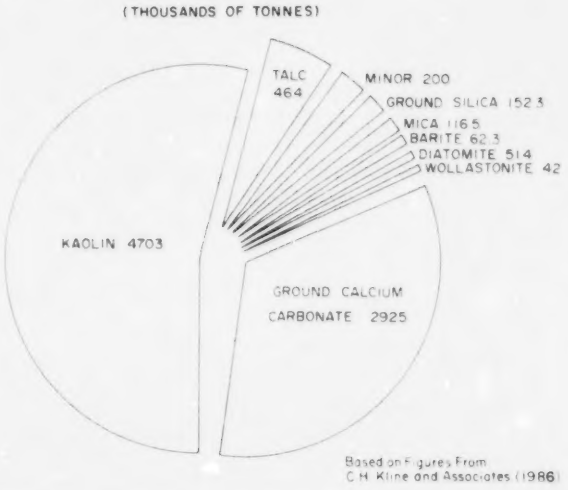


Figure 2. North American consumption of extender and filler minerals by product, 1985

PROJECT OUTLINE

Part 1 of this report describes findings from research on potential filler consumers in Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland, Maine and eastern Quebec.

First the major industry groups, including plastics, paint, paper, rubber and carpet backing manufacturers, which are the most probable users of fillers, were identified. From these groupings, industry names, numbers and contacts were taken out of manufacturers guides for Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Maine. Out of Province companies with only a small number of employees were not contacted because it was evident that only the manufacturers with larger operations dealt with actual raw materials. In Nova Scotia, all potential users were identified and contacted regardless of employment figures.

Part 2 is an assessment of deposits. It begins with a review of previous work on several mineral deposits and occurrences in the Province. This is followed by field and sample investigations and lab testing. The focus of the study is on barite, diatomaceous earth, kaoline, muscovite, ground silica and calcium carbonate deposits with some attention being directed towards talc, titanium bearing minerals and wollastonite.

A bibliography of reports and articles on fillers and extenders has been amassed and is included in the back.

PART 1. MARKET STUDY

PLASTICS INDUSTRY

Plastic resins are derived most commonly from natural gas and petroleum. They are processed from one of the following six main organic based chemicals produced in the refining of crude oil: ethylene, propylene, butoadiene, benzene, toluene and xylene.

Resins are generally classified under two major headings, **thermoplastics** and **thermosetting plastics**. **Thermoplastics** are resins that can be repeatedly moulded and softened using heat. **Thermosetting plastics** are resins that can be moulded only once.

Thermoplastics are the most popular type used in local Nova Scotia industry. Polyethylene and polypropylene are two of the most widely used resins.

Various methods are used to manufacture the numerous plastic products available. Three are quite prevalent in local industries: extrusion, injection moulding and blow moulding. The **extrusion** process is in use at Polymer International in Truro. Thermoplastic pellets are fed into a hopper and passed through a heating chamber. The hot plastic liquid is then forced out an opening to form sheets of plastic.

Injection moulding is used at most of the smaller manufacturers in the Province and at the large Can-Am Containers' plant in Springhill. The resin pellets are fed into a hopper, heated and forced into a steel cast mould. For products such as small containers, one cast might have six separate moulds in it, and the processing of one cast may take no more than 15 seconds.

Can-Am Containers' plant, Springhill, also uses the **blow moulding** process for the production of large hollow containers or barrels. Injected air forces the resin film to stretch and harden against a mould.

Without the use of additives to plastics a product is restricted by the properties of the resin and machinery. Advantages of using mineral fillers in plastic products include reinforcement, cost savings and eventual energy savings (lighter plastics product vs. heavier metal product). Disadvantages of using mineral fillers are few, but important to some local producers. For example the disadvantages of calcium carbonate are its possible subjection to acid attack and evolvement of CO_2. It also can cause brittleness in an end product. Chemical bonding compounds called coupling agents can, in some cases, be combined with the mineral fillers and actually improve impact strength, promote adhesion, and lessen brittleness in a product.

Nova Scotia plastics industries consume a combined total of approximately 11.5 thousand t of plastic resin per year. The majority of that figure is polyethylene followed by polypropylene. Plastic resin costs approximately $1000/tonne; a suitable filler would mean a dramatic cost savings because a filler mineral would unlikely exceed $250/tonne. One of the main hurdles in producing a local mineral for this industry is the resin to filler bonding factor.

Local Manufacturers

Plastic producers in the Atlantic region are mostly found in Nova Scotia, with the exception of a few small manufacturers located in New Brunswick and Newfoundland. Contact was restricted to Nova Scotia producers (Table 2).

Table 2. Nova Scotia plastic producers, 1986.

Company	Number of Employees	Contact
Reinforced Plastics Systems Inc., ABCO Plastics Division, Mahone Bay	140	Ron Corkum, Purchasing Agent
Chester Plastics, Chester	23	G. Nemeskeri, President
Can-Am Containers, Springhill	80	Robin Blake, Vice President
IMP Group Plastics, Stillwater Lake	18	Michael Spurr, Plant Manager
Quality Containers, Truro	20	David Lake, President
Polymer International (N.S.) Ltd., Truro	250	John Cross, Vice President

Reinforced Plastics Systems Inc., ABCO Plastics Division

ABCO Plastics Division is located in Mahone Bay, Lunenburg County, and manufactures mostly reinforced plastic products. Piping is the main product, the majority of which is reinforced with synthetic fumed silica.

Chester Plastics

Chester Plastics of Chester, Lunenburg County, manufactures small plastic products ranging from bottle caps to food trays. Because of the size of the operation, annual output and product line, mineral fillers are not used. Chester Plastics imports sheets of thermoplastic for remoulding as well as resin pellets for the end products.

Can-Am Containers

Can-Am Containers of Springhill, Cumberland County, supplies products to seven different markets. It manufactures products ranging from agricultural harvesting boxes to plastic floats using between 4.5 and 5.4 million kg per year of polyethylene, styrene and polypropylene resins. No mineral fillers are used in the processes although titanium dioxide is used as a colour coating for some of the containers.

Can-Am Containers has looked into various fillers in the past and will continue to do so in the future. A downfall of mineral fillers is that they can cause brittleness in the product, a very undesirable characteristic, especially for Can-Am Containers' product line.

IMP Group Plastics

IMP Group of Stillwater Lake, Halifax County, began operations in 1978 and produces injection moulded products such as buoys and floats for the marine industry. ABS and polyethylene plastic resins are used, and fiberglas and tire shavings act as reinforcing fillers. Both low grade fillers are cheap, local and abundant.

Quality Containers

Quality Containers, Truro, Colchester County, primarily manufactures products for the local dairy companies. Both high and low density polyethylene resins (almost 0.45 million kg per year) are used. No filler is used by Quality Containers because of brittleness and quality control.

Polymer International (N.S.) Ltd.

Polymer International (N.S.) Ltd. of Truro, Colchester County, is the largest plastics manufacturer in the Province. They consume almost 0.45 million kg a month of polyethylene and polypropylene, manufacturing high strength woven bags and various other products. They use over 60 000 kg per year of calcium carbonate filler (Hydrocarb 30T) as a reinforcing agent with the polypropylene. The filler is supplied by Omya of Vermont. The powdered filler is first processed to allow proper coupling between the mineral and plastic resin. The processed and pelletized filler called Masterbatch is 88% $CaCO_3$ and 12% bonding polymer which also leaves the calcium carbonate chemically inert.

PAINT INDUSTRY

Paint is an agglomeration of **resins, solvents, fillers** and **pigments**. The **resins** such as vinyl and acrylics are the backbone of the paint and give the product its own unique properties. The **solvents** account for approximately half of the total volume of the paint. Solvents generally evaporate when the paint is applied and act only as a medium into which all of the resins, pigments and fillers can be mixed. Kerosene and varsol are two of the more popular solvents.

Fillers or inerts main purpose is to add support to the film structure of the paint. In an average 4 l can of paint weighing 1.8 kg approximately one-half of that weight is supplied by the filler. Calcium carbonate, talc and kaolin are the most commonly used filler materials, but usually more than 3 or 4 different fillers are used in a mixture of paint. The term extender is also applied here since the mineral can act to extend the properties of the paint, i.e. flatness, resistance to abrasion.

Titanium dioxide is the most widely used colouring **pigment** in the paint industry. Chromium compounds, zinc oxide and other super fine pigments give the paint its colour. Because of the small particle size ($<1\ \mu m$) only minor amounts are required. To assure proper pigment coating, an old style ball mill or a conventional pigment dispersion mill is usually the final step before sealing the product for shipment.

Critical specifications for paint fillers and extenders relate to cost, purity, brightness, oil absorption, particle size distribution, low abrasiveness, inertness, density and resistance to weathering.

Calcium carbonate, kaolin, talc, titanium dioxide, barite, diatomite, nepheline syenite and ground silica are all employed locally. Calcium carbonate is used in

the greatest portions. A summary of the minerals used locally and their own desirable qualities follows:

Calcium carbonate increases viscosity, lowers cost, acts as a flattening agent (rough grind size), adds solids, provides brightness (fine grind size) and opacity. Limiting factor is its reactive nature to acidic environments.

Kaolin acts as a primary titanium dioxide extender, increases abrasive resistance of paint and has good hiding ability. Limiting factor is that its high oil absorption makes it difficult to remove stains from the paint.

Talc reinforces paint film to reduce cracking and acts as a flattening agent. Limiting factor is that it causes chalking on the surface as the film erodes.

Titanium dioxide provides whiteness and brightness that are unparalleled, and it has the highest dry hiding ability. It is a colour pigment for all the white and off white products such as pastels.

Barite has low oil absorption, high density, good sanding quality, chemical inertness and resistance. Barite is good for metal primers, but poor for architectural coatings because of its high density.

Diatomite is an effective flattening agent because of irregular shape and porosity. It also reduces drying time.

Nepheline syenite is low cost and improves abrasion resistance.

Silica makes a paint more resistant to scrubbing, is chemically inert and has low oil absorption. Limiting factor is its abrasiveness to paint mixing equipment.

The paint industry is definitely the most diverse of the manufacturers studied in terms of types of fillers used, quality specifications and incorporation of the minerals into the products. Mineral filler consumption probably approaches 1000 t per year in the local industry with calcium carbonate accounting for the bulk of that figure.

Local Manufacturers

There are four paint manufacturers operating in the Atlantic region. The largest, Matchless Paint, St. John's, Newfoundland, supplies a nation wide market. The smallest, Northumberland Paints, Charlottetown, Prince Edward Island, supplies local Island consumers (Table 3).

Matchless Paint Inc.

Matchless Paint Inc., St. John's, Newfoundland, is the largest paint manufacturer east of Toronto and is the only plant operated by the company in all of Canada. Annual production figures are unavailable, but the company contributes to a large nation wide market.

Matchless uses approximately 0.34 million kg per year of filler minerals in their manufacturing. Calcium carbonate is consumed at a rate of approximately 136 080 kg per year. It is added to nearly all paints from flat to glossy mainly because of its controlled particle size distribution. Four different product lines of calcium carbonate are used at Matchless.

The bulk of calcium carbonate filler is supplied by the Tompson Weinman Company of Georgia. The plant consumes over 100 000 kg annually of the products Snowflake Whiting, Atomite and Satin Tone W. Much less Satin Tone W is used than the former two. These are all high grade fillers, some finer and having a higher brightness than others.

Table 3. Atlantic region's paint manufacturers, 1986.

Company	Number of Employees	Contact
Matchless Paint Inc., St. John's, Newfoundland	N/A	Tony Bantleman, Chemist
Tibbetts Paint Ltd., Trenton, Nova Scotia	47	Ed Carrigan, Purchasing Department
Northumberland Paints, Charlottetown, Prince Edward Island	11	Neville McKittrick, President
Laurentide Chemicals, Richibucto, New Brunswick	~30	Dolly Stewart, Chemist

The other supplier of carbonate filler is the Steep Rock Calcite Company, Perth, Ontario. The plant uses almost 20 000 kg of their product Snowhite 40B annually.

Almost the same amount of talc filler as calcium carbonate is used by Matchless. The product Nytal 300 is supplied by R.T. Vanderbilt Company of Connecticut. It is a popular filler because of its colour, chemical inertness and viscosity.

Also used by Matchless in large portions (45 000 kg annually) is nepheline syenite, supplied by Indusmin of Lakeside, Ontario. Kaolin, which is quite popular with the other paint manufacturers, is used very little by Matchless as is barite.

Tibbetts Paint Ltd.

Tibbetts Paint Ltd. of Trenton, Pictou County, was established in 1947 and is Nova Scotia's only paint producer. Approximately 0.59 million kg of filler are consumed per year at the plant, most of which is calcium carbonate.

Calcium carbonate consumption is more than 400 000 kg per year dependent upon road and highway painting contracts awarded to the company. The calcium carbonate is mainly consumed by Tibbetts in the lower quality paints used for the road and highway contracts. Tibbetts Paint mostly uses Snowhite 452 from Steep Rock Calcite Company, Perth, Ontario, as medium grade filler. Snowhite 10-1, another Steep Rock product used, is a finer grade filler. The carbonate is delivered to Tibbetts for a total cost of which half is for freight.

Talc is consumed in the next highest proportions, at approximately 180 000 kg per year. The filler, International 325, from R. T. Vanderbilt of Connecticut, is used mostly for primer paints at Tibbetts. Another talc product, Mistron Monomix, made by Cyprus of Montana, is a finely dispersed talc and is used sparingly in specialty paints for its softness which contributes minimum abrasion to the system. It also disperses readily in both solvent and water based paints. This product is about twice as expensive as calcium carbonate fillers.

Tibbetts uses approximately 18 000 kg of kaolin in their manufacturing. ASP400 from Pigment Chemicals Englehart Division, Georgia, is a delaminated kaolin meaning it is produced by splitting apart the compressed platelets that comprise a kaolin particle. Delaminated kaolin is used extensively in interior latex paints.

Minor amounts of barite supplied by Nystone Chemicals of Debert, Nova Scotia, and diatomite supplied by Manville Corporation of Denver, Colorado, are also used in the plant. Use of these two materials is not expected to increase in the near future.

Northumberland Paints

Northumberland Paints located in Charlottetown have been in production for 18 years and rely on the local Prince Edward Island market for paint sales.

Annual consumption of filler and extender minerals at the Northumberland plant is approximately 110 000 kg. Calcium carbonate and talc account for over two thirds of that figure and ground silica, kaolin, nepheline syenite and minor amounts of barite and diatomite constitute the rest.

Calcium carbonate (approximately 45 000 kg/year) is supplied by Thompson Weinman Company who mine their products in Georgia. Two grades of carbonate are used at the plant: Atomite, which is also used at the Matchless plant; and Drikalite, which has a larger mean particle size than the very fine Atomite.

Talc used at Northumberland is mined by R. T. Vanderbilt operating out of New York. Approximately 36 000 kg per year are used. Three grades, each varying in particle size, are consumed.

Silica is consumed at the rate of 18 000 kg per year and Northumberland is apparently the only Atlantic Canadian manufacturer using ground silica. Tammsco Inc., operating out of Illinois, produces Silver Bond B from pure white silica sand and supplies Northumberland Paints. It finds its greatest application in exterior coatings.

Indusmin of Lakefield, Ontario, supplies almost 7000 kg annually of nepheline syenite. The same amount of kaolin is used annually and is provided by Englehart Division who operate mines and plants in Georgia.

Very minor amounts (approximately 500 kg/year) of barite from Pfizer Inc. of New York and almost the same amount of celite diatomite from Manville of Colorado are also used at the plant.

Laurentide Chemicals

Laurentide Chemicals located in Richibucto, New Brunswick, is the Atlantic Division of the Quebec based firm. Similar to the other paint manufacturers they produce both industrial and domestic paints, varnishes and stains. Specifications on mineral consumption are not available, nor is the operation size.

PAPER INDUSTRY

Figure 1 shows that the paper industry is by far the leading consumer of fillers and extenders. In paper manufacturing a mineral can act as **filler, extender** or **coater**. A **filler** replaces more expensive wood fibre within the paper's structure, an **extender** extends titanium dioxide pigment in various printing and writing papers, and a **coater** puts a thin film or sheen on the paper. A coater must be nonabrasive, have high brightness and small particle size to be effective. Kaolin is the leading extender, filler and coater used by the paper industry. Four different varieties of kaolin are used which include **air floated kaolin, water washed kaolin, delaminated kaolin** and **calcined kaolin**.

Air floated kaolin involves the least amount of processing. The kaolin is dried, ground and air floated to separate the heavier impurities from the kaolin particles. Used as a filler in paper, its lower brightness limits its use in finer coated sheets.

Water washed kaolin involves crushing, screening and centrifugally sorting raw kaolin to the desired particle size. A magnetic separator then removes remaining impurities and subsequent chemical treatment enhances the brightness and colour. Water washed kaolin is used as both a filler and coater in paper. The two grades, filler and coater, are distinguished on the basis of brightness and particle size. Water washed is the leading pigment used in the paper industry.

Delaminated kaolin is produced from the coarser particles separated in the processing of water washed kaolin. The particles are subjected to pressures causing splitting along structural planes. Impurities are removed and the end product is a better quality than water washed kaolin. Coating in paper is the major application for delaminated kaolin because its wide, thin particles enhance ink receptivity, brightness and colour.

Calcined kaolin is produced by subjecting the ground kaolin to intense heat which removes the water from the mineral leaving it brighter and more abrasive than the previous product. Usually water washed kaolin is used in this process. It is used as a filler in the manufacture of paper because of its brightness and as a titanium dioxide extender. It can also be used as a coater.

Other major mineral fillers finding applications in the paper industry in order of 1984 North American consumption are: calcium-carbonate, both ground and precipitated, titanium dioxide (as pigment/whitener), talc, precipitated silicates and alumina hydrate (pigment/whitener) (C. H. Kline and Associates, 1985).

Talc is used in a high percentage of paper mills, as a processing aid, though it can be used as a filler. It is used as a pitch disperser. Pitch is organic contaminants in wood fibre. Talc prevents pitch agglomeration which can cause spotty paper or can clog the machinery.

Alkaline Sizing in the Paper Industry

Although calcium carbonate has sales of approximately 400 000 t per year in North America as a coater and filler, it does encounter problems in its chemical reactivity in an acidic environment. Many paper producers use an acidic process which discounts the use of calcium carbonate. However, increased paper consumption and resource limitations may be underlying a trend for producers to switch to alkaline paper systems.

In Europe, calcium carbonate is the filler of choice in the paper industry. Consumption of ground calcium carbonate in Western Europe has more than doubled in the past ten years replacing much of the other filler/coater minerals such as kaolin and talc.

It was predicted in the early 1980s by a number of authorities on the American paper making industry that there would be a major change in the North American fine and specialty paper industry from acid sizing to alkaline sizing (Hagemeyer and Welch, 1981).

A number of reasons were cited for this foreseeable change in America. One of the many important reasons is a reduction in water consumption. Using the acid process, water may be recycled only a few times because of an increase in dissolved salts concentration after each water reuse. This can lead to numerous problems if not replaced with fresh water. It has been reported that water consumption has been cut in half by alkaline sizing plants, because water can be recycled with very few difficulties. Acidity of the water can also be kept in check by the alkaline filler.

A number of other important advantages of alkaline sizing cited by Hagemeyer (personal communication, 1987) include a reduction in energy consumption and a better quality paper, ie. brightness, strength, permeance and reduced discolouration.

Of importance to the mineral industry is the nonrestriction on filler consumption when using the alkaline system. The acid system is restricted by its inability to incorporate calcium carbonate fillers and coaters because of their reactivity in the acid wash.

Research indicates that despite the initial excitement shown about the switch over from acid to alkaline sizing few companies have undergone the necessary equipment changes to produce using the alkaline method. Hagemeyer and Chender of Metals Economics Group, Halifax, (personal communication, 1988) both agreed that initial interest was suppressed because of economics. The switch is, in most cases, a costly procedure and requires a nearly complete shutdown. Minor problems have arisen in past switches in the American industry and many companies do not appear to be willing to slow or stop operations for a prolonged period of time.

Another problem appears to be the inability to use alum as a pitch control in the alkaline paper process. According to Hagemeyer (personal communication, 1987) many producers, who rely on alum, would have to use valuable production time to test unfamiliar procedures with alternate materials for pitch control. Other important steps such as sizing require time to learn new technology resulting in lost production time. It appears that financial and production commitments leave the industry rather hesitant to change.

Market requirements for the calcium carbonate are very stringent and the filler, coater and extender have to be of the highest grade. Ultra fine grinding ($-2\ \mu m$), high brightness and very low magnesium and silica contents are essential for paper grade carbonate.

Precipitated calcium carbonate has taken a substantial piece of the North American market from the ground equivalent. In recent years many plants with outside help began producing their own precipitated calcium carbonate. Pfizer Inc. of New York, New York, has been setting up satellite plants at the paper plant sites to calcine and reform local limestone using carbon dioxide gas. Precipitated $CaCO_3$, if the processing is perfected, can be superior to ground in particle size range, purity and brightness.

Some alkaline paper producers, depending upon the proximity of the calcium carbonate supplier, may still choose to use a kaolin filler, if delivery costs are cheaper. Ultra fine carbonate costs almost the same as the kaolin fillers.

Ten paper producers using the alkaline system were identified on the eastern seaboard from Maine south to Maryland. There appears to be only one in Eastern and Central Canada, Fraser Inc., Thorold, Ontario. In Maine, out of nearly 40 paper mills, only 2 are currently using the alkaline process.

Table 4 is a list of alkaline producers provided in part by C. H. Kline and Associates.

Table 4. Alkaline paper producers from the Eastern Seaboard of the United States and Eastern and Central Canada for 1986.

Plant, Location
Finch Pruyn, Glen Falls, New York
Fraser Inc., Thorold, Ontario
P. H. Glatfelter, Spring Grove, Pensylvania
Hammermill Paper, Lock Haven, Pensylvania
Kimberly Clark, Spotswood, New Jersey
James River, Hyde Park, Maine
Mohawk, Cohoes, New York
Potsdam Paper, Potsdam, New York
Scott Paper (S. D. Warren), Westbrook, Maine
Westvaco, Luke, Maryland

Contact was made with a couple of the alkaline producers to get an idea of consumption figures and mineral product used. At Scott Paper in Westbrook, Maine, a product supplied by Omya Inc. of Vermont called Hydrocarb 65 is consumed at a rate of over 13 000 kg per year (Cathy Knox, personal communication, 1987).

Finch Pruyn, Glen Falls, New York, has their own precipitated calcium carbonate plant beside the main paper manufacturing complex.

Sumner, of P. H. Glatfelter, Spring Grove, Pennsylvania, (personal communication, 1987) described precipitated calcium carbonate (PCC) as being 'the wave of the future' and it is all his plant is using. He also felt that most plants using the alkaline process were consuming PCC.

Despite the slowness with which the North American paper industry is moving to alkaline sizing it appears to be an inevitable shift and the possibility of market potential for paper grade filler calcium carbonate from Nova Scotia should exist. More information on the present state of the industry may be available through the manufacturers or by referring to the enclosed bibliography for papers and reports on alkaline paper processing.

Local Manufacturers

A total of 38 pulp and paper producers were approached in the study area (Table 5; Fig. 3). Manufacturers guides to Maine and Quebec were referenced for the producers. Of that number, 16 are located in Maine, 9 in Quebec, 7 in New Brunswick, 4 in Nova Scotia and 3 in Newfoundland. Letters were sent to the 25 Maine and Quebec producers, but only 8 replies were received. Detailed information on mineral pigment use was requested. Those companies operating in New Brunswick, Newfoundland and Nova Scotia were interviewed by telephone.

The product line of the plant gives some idea whether or not the company is using fillers. Newsprint does not warrant their use, but fine and specialty papers probably have some filler or coater in them. W. D. Kerr, Fraser Inc., (personal communication, 1988) mentioned that an average magazine sheet is composed of approximately one-third clay by weight.

Nova Scotia has four pulp and paper producers. Unfortunately, none of their products warrant the use of mineral fillers. Bowater Mersey, Liverpool, and Stora Forest Ltd., Port Hawkesbury, each produce newsprint, supplying local and foreign markets. Newsprint, because it is low grade, may only find the need for colourant to make it whiter, but filling or coating is not necessary.

Stora Forests Ltd. does use talc for pitch control as does Scott Paper, New Glasgow, which produces Kraft pulp. Bowater Mersey makes use of a chemical disperser, having switched from talc a few years ago. The fourth manufacturer, Minas Basin Pulp and Paper, Hantsport, produces mostly boxboard and, like Bowater Mersey, uses a chemical disperser for pitch control. It is not foreseeable that any of these companies will be using minerals in the future unless product lines are changed.

The same holds true for New Brunswick and Newfoundland pulp and paper producers. Most of them are newsprint manufacturers with the exception of the Miramichi Pulp and Paper Inc., Newcastle, New Brunswick, owned by Repap which has just recently switched from being a newsprint producer to a fine paper producer.

At Miramichi, up to 200 t per day of Georgia kaolin are expected to be consumed once operation comes into full working capacity. Half of this will be used as a coater and half as a filler for the base sheets. The clay constitutes one third of the paper content. Equal portions of groundwood pulp and thermomechanically produced pulp make up the other two thirds.

The paper produced by Miramichi will be used in magazines and newspaper flyers and shipped to markets along the Atlantic Seaboard. Presently, transport to and from the plant is by rail, but changes such as new storage tanks are being made to accommodate delivery by ship.

In March 1988 it was announced that the Miramichi plant will be undergoing further upgrading to make it one of the top five fine paper producers in North America. Alkaline sizing will be incorporated at the plant and provide a high potential tonnage market for a high purity limestone.

Since practically all of the kaolin used in the Maine plants comes from Georgia it appears that local deposits of suitable grade kaolin and calcium carbonate would be quite profitable with markets already in place.

RUBBER INDUSTRY

Figures for 1985 show that the rubber industry as well as the carpet industry are the fifth largest consumers of extender and filler minerals in North America. Although consumption figures are high, the industry also uses a greater quantity of nonmineral fillers in the manufacturing processes.

Both synthetic and natural rubber can use fillers. The two most commonly used nonmineral or synthetically produced fillers are carbon black and silica dust.

Carbon black is inexpensive to produce by pyrolysis or breaking down of hydrocarbons. It is the premiere rubber filler because of its small particle size, reinforcing properties, low cost, easy method of production and black colour.

Silica dust, which is produced by the fuming of silicon chloride, is used to a lesser degree than carbon

Table 5. Pulp and paper producers in Eastern Canada and Maine, 1986. See Figure 3 for location of producers.

#	COMPANY	LOCATION	CONTACT MADE	PRODUCT	FILLER APPLICATION
1	Abitibi Price Inc.	Grand Falls, Newfoundland	F. Duquette	newsprint	no
2	Cornerbrook Pulp and Paper	Cornerbrook, Newfoundland	Harvey Hitchcock	newsprint	no
3	Abitibi Price Inc.	Stephenville, Newfoundland	F. Duquette	newsprint	no
4	Stora Forest Ltd.	Port Hawkesbury, Nova Scotia	Lawrence Welch	newsprint	no, 2177 t/annum talc for pitch control
5	Scott Paper	New Glasgow, Nova Scotia		kraft pulp	no, talc is used for pitch control
6	Minas Basin Pulp and Paper	Hantsport, Nova Scotia		boxboard	no
7	Bowater Mersey	Liverpool, Nova Scotia	Harold Dobson	newsprint	no
8	Irving Pulp and Paper	Saint John, New Brunswick	R. F. Royal	kraft pulp	no, talc is used for pitch control
9	Rothesay Paper	Saint John, New Brunswick	Brian Ellick	newsprint	no
10	St. Anne Nackawic Pulp and Paper	Nackawic, New Brunswick		wood pulp	no
11	Miramichi Pulp and Paper Inc.	Newcastle, New Brunswick	W. Roepke	fine paper	200 t/day kaolin
12	Consolidated Bathurst	Bathurst, New Brunswick		wood pulp	no
13	NBIP Ltd.	Dalhousie, New Brunswick	John Davis	newsprint	no
14	Consolidated Bathurst	New Richmond, Quebec	A. M. Ayroud	paperboard	clay use is being considered
15	Caspecia Ltd.	Chandler, Quebec	Allan Vatcher	newsprint	clay use is being considered, talc for pitch control used until recently, 4218.5 kg/day
16	CIP Inc.	Matane, Quebec	no return correspondence	paperboard	not probable
17	QNS Paper	Baie-Comeau, Quebec	no return correspondence	newsprint	not probable
18	Soucy Inc.	Riviere-du-loup, Quebec	no return correspondence	newsprint	not probable
19	Donohue Inc.	Clermont, Quebec	André Marcoux	newsprint	no
20	Cascade Inc.	Jonquiere, Quebec	no return correspondence	paperboard	not probable
21	Price Co.	Alma, Quebec	no return correspondence	newsprint	not probable
22	Consolidated Bathurst	La Baie, Quebec	Pierre Bédard	newsprint	no
23	Fraser Inc.	Madawaska, Maine	W. D. Kerr	specialty paper	54 431.4 t clay/annum
		Atholville, Maine (33)	W. D. Kerr	pulp	no, 417 3 t/annum of talc for pitch control
		Edmunston, New Brunswick	W. D. Kerr	pulp	no, 363 t/annum of talc for pitch control
24	Great Northern Paper	Millinocket, Maine	Opal M. Arnold	specialty paper and newsprint	363 t filler clay/annum
25	Great Northern Paper	East Millinocket, Maine	no return correspondence	specialty paper and newsprint	filler use is likely
26	Lincoln Pulp and Paper	Lincoln, Maine	Carl G. Hamilton	fine paper	635 t filler clay/annum
27	Georgia Pacific Paper	Baileyville, Maine	no return correspondence	no product specifications	
28	Eastern Paper Co.	Brewer, Maine	no return correspondence	fine paper	filler use is likely
29	Champion International	Bucksport, Maine	no return correspondence	printing paper	filler use is likely
30	S.D. Warren Co.	Skowhegan, Maine	no return correspondence	fine and specialty paper	filler use is likely
31	Madison Paper Co.	Madison, Maine	no return correspondence	printing paper	filler use is likely
32	International Paper Co.	Jay, Maine	no return correspondence	no product specifications	filler use is likely
34	Statler Tissue Co.	Augusta, Maine	no return correspondence	paper towels, napkins, tissues	filler use is likely
35	Pejepscot Paper Div.	Topsham, Maine	no return correspondence	no product specifications	
36	S.D. Warren Co.	Westbrook, Maine	no return correspondence	coated paper	filler use is likely
37	Marcel Paper Mills	Mechanic Falls, Maine	no return correspondence	fine and specialty paper	filler use is likely
38	Boise Cascae Paper	Rumford, Maine	B. Melanson	no product specifications	7257.5 t filler clay/annum 2540 t talc/annum

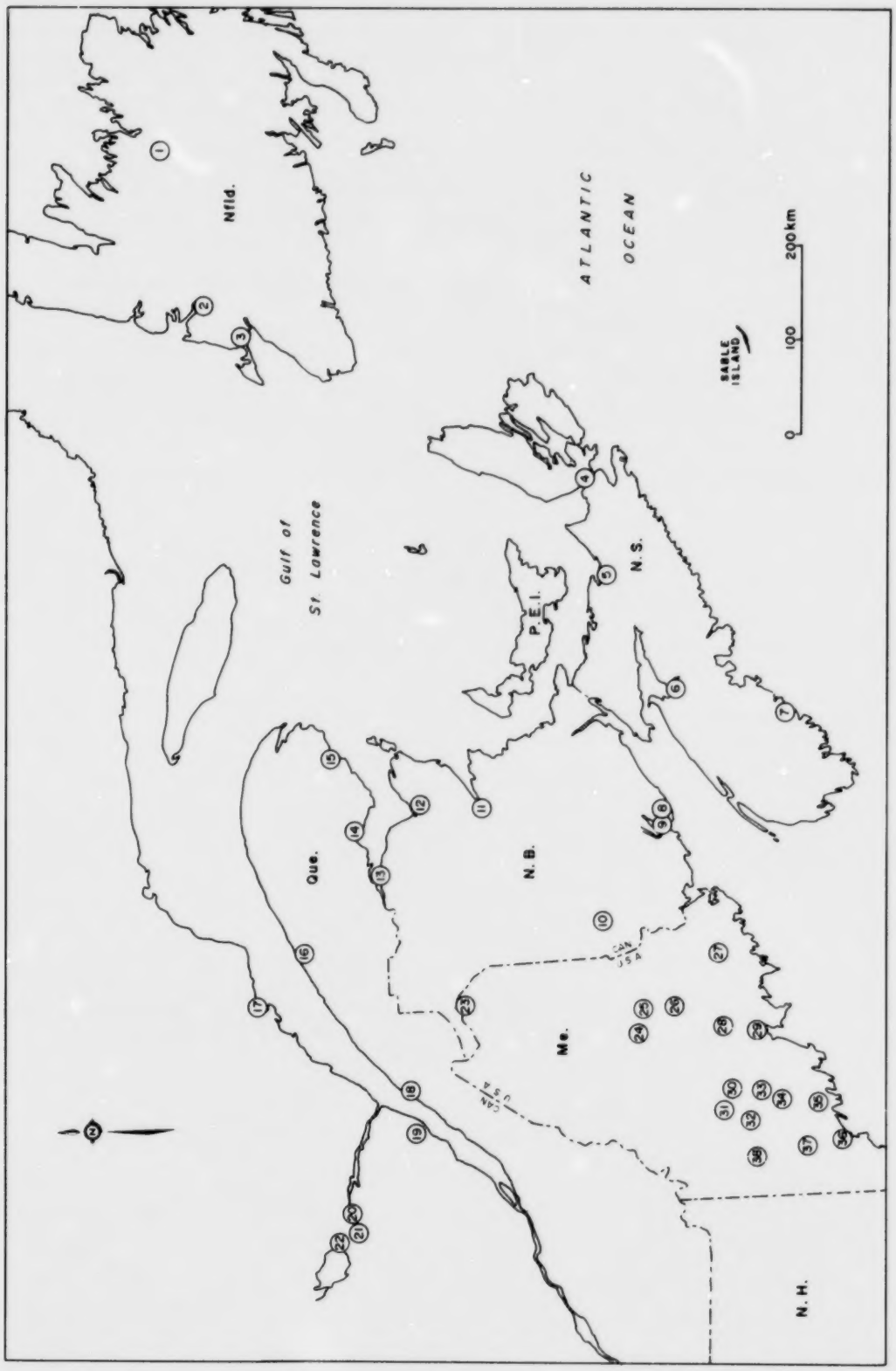


Figure 3. Location map of pulp and paper producers in Eastern Canada and Maine, 1986. See Table 5 for key to producers.

black and finds its major application in large off road tires. The dust improves cut-resistance in the tires.

The most popular mineral filler for rubber is kaolin. Kaolin can improve strength, rigidity and abrasion resistance. Two types, hard kaolin and soft kaolin are used in the rubber industry. Hard kaolin improves tensile strength. Soft kaolin is used in products not requiring reinforcement.

Other less used mineral fillers include calcium carbonate, talc, mica and barite. Minor applications for a wide variety of minerals can be found, but problems occur when the different minerals are bonded with the rubber compounds. Other additives and bonding agents are required, reducing the desirability of many minerals.

MacKillop and Myhre (1981) predicted that mineral fillers will play a much greater role in the future at the expense of carbon black and silica dust. He cited improved grinding and refining techniques as well as lower cost coupling agents as two major reasons for this shift.

Local Manufacturers

In the Atlantic region the rubber industry, considering number of producers, is not a large one (Table 6). Indeed, the only company that handles raw material is Michelin Tire, Nova Scotia. Another company, Town Tire, Dartmouth, also handles premoulded rubber compounds, but additives such as fillers have already been mixed into their rubber.

Michelin Tire

Michelin Tire (Canada) operates three plants in Nova Scotia, one in Granton, Pictou County, one in Bridgewater, Lunenburg County, and one in Cambridge Station, Kings County. They mix their own rubber compounds in the plants to manufacture a wide variety of tires for cars, trucks and buses.

Natural rubber is brought to Nova Scotia in block form from different countries in Southeast Asia. These large blocks are coated in talc to stop them from sticking together. They are chipped down to a much smaller size at the plant, applying talc for the same reason. Talc therefore makes up a very small percentage of the final compound.

The fillers which Michelin adds to the rubber when it is heated are the nonminerals carbon black and silica dust. Carbon black is the principal reinforcing filler and accounts for approximately 30% of the average tire by weight.

Silica dust is the other filler used by Michelin, but in much smaller quantities than carbon black. Silica finds its major application in large off-road tires where it is used to improve cut-resistance.

Titanium dioxide is also used at the plant in minor amounts as a whitening agent for whitewalls.

Town Tire

Town Tire manufactures various rubber products including gaskets, bumpers and rubber seals. Rubber compounds are premixed and brought to the Dartmouth plant from Upper Canada where extruders mould the different products. The ingredients of the rubber compound are unavailable, but Mr. Himmelman, Plant Manager, suspects that kaolin may be used.

CARPET BACKING INDUSTRY

Carpet backing is the largest volume industrial application for calcium carbonate in North America. It is an industry that in 1985 consumed a total of $19.1 million or 615 000 t of calcium carbonate (C. H. Kline and Associates, 1986). Calcium carbonate is used in significant amounts as a filler because it ideally fits the requirements of having a low binder demand, low cost, abundance and can be added in large portions to the foam backing without critically increasing the viscosity.

Four other mineral fillers, barite, kaolin, talc and silica, have minor applications in the carpet backing industry, but their consumption does not approach the levels of consumption of calcium carbonate.

Table 6. Atlantic region's rubber industry, 1986.

Company	Number of Employees	Contact
Michelin Tire (Canada), Granton, Bridgewater, Cambridge Station, Nova Scotia	N/A	Yves Billioux, Quality Control Supervisor
Town Tire, Dartmouth, Nova Scotia	40	Larry Himmelman, Plant Manager

Specifications for filler grade calcium carbonate for carpet backing are much less stringent than they are for other industrial applications. High brightness values are not essential, coarser grades can be used and chemical purity is not a necessity. These factors contribute to its lower cost.

In application, the filler mineral is combined with a rubber latex system and applied directly to the underside of the carpet. Curing in the ovens and trimming completes the manufacturing process.

In most applications, two coatings of backing are applied; these vary in filler concentrations from <200 parts calcium carbonate and 100 parts dry latex up to 650+ parts calcium carbonate to 100 parts dry latex.

Local Manufacturers

Crossley Karastan Carpet Mills Ltd., Truro, is the only carpet manufacturer in the Atlantic region (Table 7). They supply carpets, both tufted and woven, to a nation wide market. The Truro plant houses approximately seven acres under its roof and has facilities for rail car delivery of essential components for its carpet backing.

Crossley Karastan is Nova Scotia's largest consumer of filler material, consuming over 1.3 thousand t per year. Industrial Fillers Ltd., Montreal, supplies the calcium carbonate used by Crossley Karastan. The product Pulpro 1 is brought to their Truro plant via rail hopper car in shipments of nearly 90 000 kg/load bimonthly. The off-loading terminal has been constructed within the past few years replacing the previous method of tanker truck delivery. This new means of transport has meant a cost savings to the company.

The plant consumes approximately 150 000 kg per month of the filler. It is stored in two large silos in the back of the plant where it is combined with latex to form the backing solution.

Previous investigations were undertaken by the Nova Scotia Research Foundation in 1976 on potential alternate sources for Pulpro 1 from the Maritime Provinces.

George River Group marble apparently tested very well at the plant, but problems were encountered in the area of transportation (i.e. contamination when using cement trucks). This report is available at the Nova Scotia Research Foundation, Dartmouth.

MARKET SUMMARY

Figure 4 shows the manufacturing industries in the Atlantic Provinces currently using filler minerals. The total tonnage of filler used in 1986 by all the industries is approximately 2000 t. Table 8 shows the consumption by company and mineral filler for the Atlantic region. Calcium carbonate is used locally in the greatest proportions, mainly because of Crossley Karastan Carpet Mills Ltd., Truro, Nova Scotia.

Figure 5 shows the proximity of mineral producers supplying local industry in the Atlantic region. Many of these products have to be shipped thousands of kilometres.

Table 7. Carpet manufacturer in the Atlantic region, 1986.

Company	Number of Employees	Contact
Crossley Karastan Carpet Mills Ltd., Truro, Nova Scotia	N/A	Ken Meyer, Plant Manager

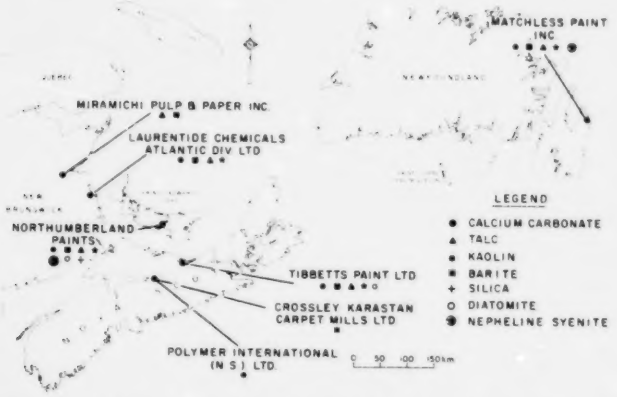


Figure 4. Major filler and extender mineral users, Atlantic region, 1986

Table 8. Estimate of Atlantic region's industrial filler consumption for 1986.

	$CaCO_3$ kg	Talc kg	Nepheline Syenite kg	Kaolin kg	Silica kg	Barite kg	Diatomite kg
Miramichi Pulp and Paper Inc.		X		200* t/day			
Polymer International (N.S.) Ltd.	60 000						
Matchless Paint Inc.	136 080	136 080	45 000	X		X	
Tibbetts Paint Ltd.	400 000	180 000		18 000		450	X
Northumberland Paint	45 000	36 000	7 000	7 000	18 000	450	500
Laurentide Chemicals Atlantic Division Ltd.	N/A**	N/A		N/A		N/A	
Crossley Karastan Carpet Mills Ltd.	1 725 500						
Total	2 366 580	352 080	52 000	25 000	18 000	900	500

Total industrial filler consumption: 2 817 060 kg

* Future estimate once production begins - not included in totals
** N/A = not available
X minor amounts used

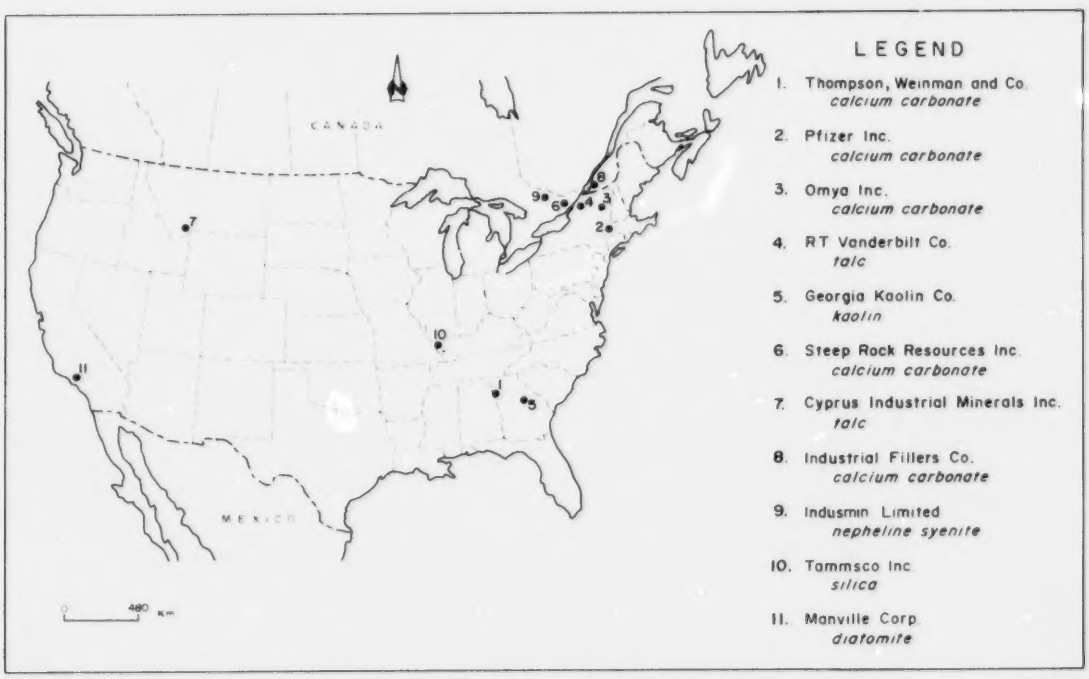

LEGEND
1. Thompson, Weinman and Co. calcium carbonate
2. Pfizer Inc. calcium carbonate
3. Omya Inc. calcium carbonate
4. RT Vanderbilt Co. talc
5. Georgia Kaolin Co. kaolin
6. Steep Rock Resources Inc. calcium carbonate
7. Cyprus Industrial Minerals Inc. talc
8. Industrial Fillers Co. calcium carbonate
9. Indusmin Limited nepheline syenite
10. Tammsco Inc. silica
11. Manville Corp. diatomite
CANADA
MEXICO
480 km

Figure 5. Principal suppliers of mineral fillers for Atlantic Canada, 1986

PART 2. FIELD STUDY

The market study (Part 1), which was the first step of the filler project, was completed in January 1987. The information provided by that study served as a guideline for initiating mineral investigation in the field. Field studies were restricted by ground staking, federal park land regulations and time. A list (Table 9) has been compiled of mineral occurrences and deposits studied where a filler application may present itself. Refer to Figure 6 for locations of each occurrence or deposit.

Table 9. List of filler mineral occurrences and deposits in Nova Scotia which were studied in 1987. See Figure 6 for location map.

Mineral	Location
Barite	Scotsville, Inverness County
Diatomaceous Earth (Anderson, 1990)	Brora Lake, Pictou County Gamble Lake Pond, Colchester County Little River (Factory Bog) Digby County
Kaolin	Hardwood Lands (West Indian Road), Hants County Chegoggin Point, Yarmouth County
Limestone and Marble	Glencoe, Inverness County Marble Mountain, Inverness County
Muscovite	Port Mouton, Queens County Mica Hill, Victoria County Chegoggin Point, Yarmouth County
Titanium Sands (MacDonald, 1989)	Shubenacadie River, Colchester County
Wollastonite	Lime Hill, Inverness County
Talc (MacDonald, in prep.(a))	Stirling, Richmond County Soapstone Brook, Victoria County Soapstone Mine, Inverness County
Silica (MacDonald, in prep.(b))	Chegoggin Point, Yarmouth County

Calcium carbonate is the dominant filler material used in the Atlantic Provinces. For this reason and the fact that Nova Scotia has some quality limestone and marble deposits, calcium carbonate was the most important commodity to investigate.

Other indigenous minerals and their potential to reach marketable grade were also investigated during the field study. Some (barite, talc, kaolin, silica and diatomaceous earth) are used in local industry, but the total tonnage consumed tends to be small and an operation providing filler grade of each mineral would have to look to Upper Canada or the United States for markets. After the in situ grade was determined then further study could be undertaken to determine whether beneficiation was required to meet market standard, and finally an estimate on available tonnage was made if the material did show potential.

Analyses were conducted by the Minerals Engineering Centre of the Technical University of Nova Scotia, Halifax. Lab procedures for limestone analysis involved calcium determination by E.D.T.A. titration and silica by colourmetric method. Magnesium, alumina and iron were all determined by atomic absorption. A few more complex analyses were completed at the Canada Centre for Mineral and Energy Technology in Ottawa and by English China Clay in Georgia. Fine grinding tests were completed on some of the samples acquired

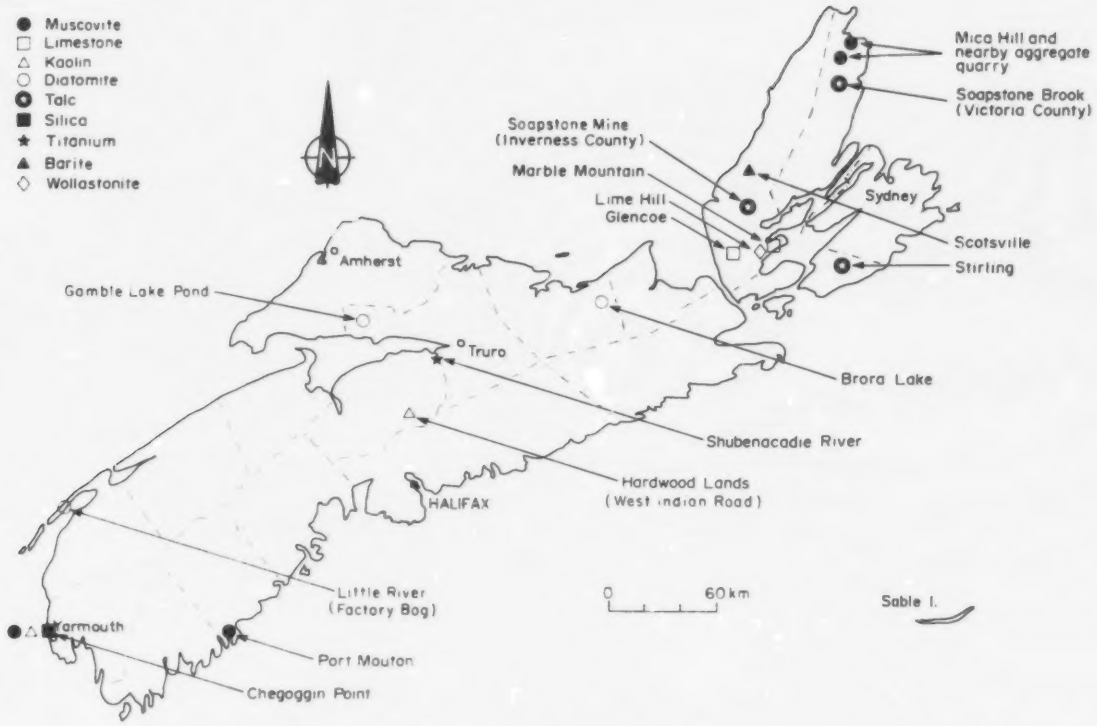


Figure 6. Field study location map, 1987

during the spring/summer 1987 by the late Mr. Dennis Stone of Magstone Development Corporation, Debert, Nova Scotia.

BARITE

Barite ($BaSO_4$) can occur in various geological settings including all three of the major rock types. The majority though tends to occur as replacements in sedimentary rocks. It is characterized by its high specific gravity (4.5).

The majority of the worlds barite production, since the early 1920s, has been for its role as a weighting agent in the muds circulated in gas and oil well drilling. Barite is ideally suited for this because it is nonabrasive, chemically inert, heavy, clean and inexpensive compared to many other available heavy materials.

Barite's major role as a filler is in the plastics industry. It is used mostly to increase the specific gravity of the end product such as home appliance base parts. In paints, barite makes a very good filler for primer paints, but its high density is a detriment for use as an indoor or outdoor paint (Fig. 7).

Local Resources

Nova Scotia has well over 50 occurrences of barite throughout the Province and one operating quarry in Brookfield, Colchester County. This barite is eventually processed into a pharmaceutical grade. Very small amounts are used by the local paint manufacturers as a filler.

Some of the highest grade barite in Nova Scotia can be found on the shores of East Lake Ainslie, Inverness County, in the Scotsville area (Fig. 6). This vein deposit nearly reached production before a drop in the offshore exploration activity in the early 1980s crippled the local demand for barite.

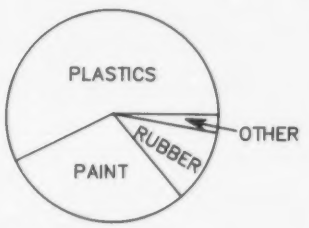


Figure 7. 1985 North American consumption of barite (Total = 64 864 t)

Nystone Chemicals, Brookfield, Colchester County, have shown barite production does not have to be solely reliant on the oil drilling industry. A high quality stone such as the Scotsville barite could supply other markets such as the filler industry.

DIATOMACEOUS EARTH

Diatomaceous earth is a sediment principally consisting of the fossilized siliceous skeletal remains of the diatom. The diatom is a unicellular aquatic plant related to algae. There are numerous species of diatoms, each varying in size and shape. The species type is very important in determining the possible end uses of the diatomite. Diatomite can be identified in water basins throughout the world, but only with the ideal environmental conditions can it be found in economic quality and quantity. Essential are a large shallow basin for deposition, abundant supply of soluble silica and nutrients and the absence of growth inhibiting constituents and clastic material.

Diatomite has a unique particulate structure and chemical stability, so it can be used for particular industrial applications where other forms of silica are unacceptable. A filter aid in liquid (i.e. beer, wine) processing is a prime example of such an application. Diatomite's high absorptive capacity, high surface area, low abrasiveness and low density make it an ideal filler in the paint industry for flat paints (Fig. 8).

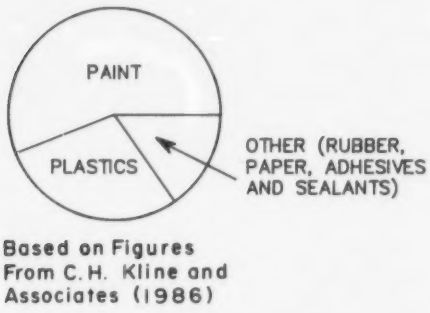


Figure 8. 1985 North American consumption of diatomite (Total = 50 349 t)

Local Resources

An extensive study of diatomite occurrences was undertaken in 1987-88 by the Nova Scotia Department of Mines and Energy under the supervision of A. R. Anderson. Anderson (personal communication, 1988) found significant occurrences of quality diatomaceous earth in over 18 lakes throughout the Province.

The majority of these occur in the Cobequid Highlands between Springhill and Earltown. Brora Lake, Pictou County, may have the best potential for development for mining of diatomaceous earth as a possible filter or carrying agent for insecticides (Fig. 6) (Anderson, personal communication, 1988). Applications as a filler would require more testing.

Diatomaceous earth at Brora Lake and indeed all diatomaceous earth in Nova Scotia is derived from the Pinnate species with a mean particle size range of 12-15 μm which is a bit oversized for most filler applications. Generally, diatomaceous earth in Nova Scotia is highly fragmented. The ideal diatomite filler consists of nonfragmented diatoms. Further research may reveal other more suitable uses for Nova Scotia's diatomite.

Local industrial consumption of filler diatomite is minor, but could increase if local diatomite was produced. A small, but feasible, market opening exists for a local producer of diatomite as a filter and carrying agent.

KAOLIN

Kaolin consumption in the filler and extender industry by far exceeds the use of any other industrial minerals. There are four grades of kaolin, water washed, air floated, delaminated and calcined, produced from different types of processing that the crude kaolin undergoes (Fig. 9). Prices vary for each.

Kaolin's major applications are as a filler in industries such as paper, plastics and paint. The platy crystal structure, natural binding ability and high brightness make it acceptable for many uses. Kaolin is used in ceramics where it acts as the primary structural component as well as a pigment and binder. The mineral also is used in brick making, refractories and even in the electronics industry.

Georgia and South Carolina have the highest quality and most easily processed kaolin deposits of North America (C. H. Kline and Associates, 1986). These deposits supply over 90% of the filler and extender kaolin in North America.

There are two types of kaolin on the basis of genesis, primary and secondary. Primary deposits are developed in situ by the alteration of minerals such as feldspar or other aluminum silicates to kaolin. Secondary kaolin is deposited as sediment. Secondary kaolin, in the form of sedimentary deposits, yields the majority of kaolin which is used in the filler and extender industry. These deposits should be a neutral colour because only the white kaolin is widely used.

Local Resources

In Nova Scotia the Cretaceous deposits of the Musquodoboit and Shubenacadie Valleys contain, not only sand with a purity of 95%+ silica, but also play host to kaolinitic clay beds of various colours.

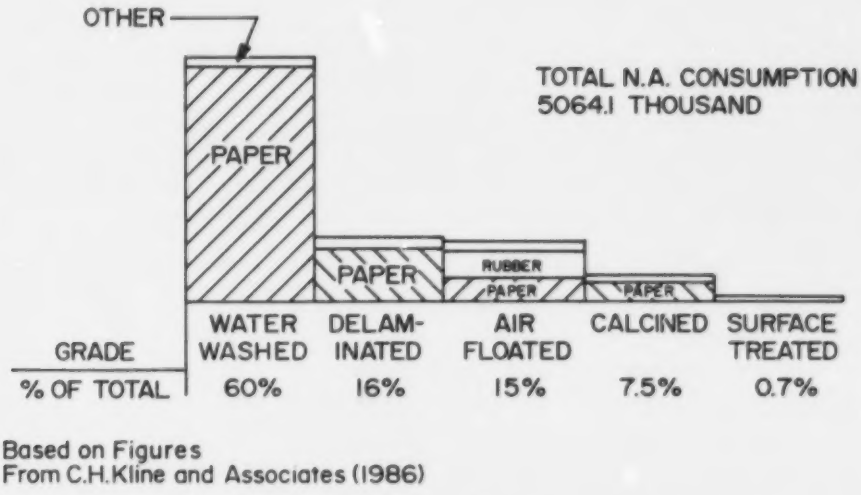


Figure 9. 1985 North American consumption of kaolin (Total= 4 594 101 t)

Postdepositional weathering of the original soils to form these high purity deposits involved rainwater reducing the feldspar in the soil to kaolinite and transporting this and dissolved silica, out of the system. Initially these clay beds may have been deposited as montmorillonite and kaolinite, then altered by deep weathering to produce pure kaolinite.

These deposits appear to be the only major source of kaolin in the Province, although altered granites such as those found at the East Kemptville Tin Mine were also looked at briefly for their kaolinitization.

Colours of the Musquodoboit and Shubenacadie clays vary from black to reddish to buff. The area chosen to more closely examine the kaolin was at the West Indian Road silica pit at Hardwood Lands, Hants County (Fig. 6). This Cretaceous deposit is confined to a large sinkhole with deformed lenses and beds of light purplish-grey kaolin.

The pit owner and operator, Nova Scotia Sand and Gravel, has removed and stockpiled the kaolin while extracting the silica sand for processing. The stockpile is easily accessible and light coloured. Samples were taken from West Indian Road for analysis. Kaolin lenses in the pit are over 1.8 m thick in places, but pinching and swelling makes them impossible to trace. This makes a tonnage estimation impossible without detailed drilling and mapping.

A 45 kg sample was taken from the kaolin waste pile and another much smaller sample (25 kg) was extracted from the settling pond of the silica sand wash plant at West Indian Road. These were analyzed at the Technical University of Nova Scotia, Halifax, for clay content and elemental analysis (Table 10).

A 9 kg sample from the waste pile was subsequently sent to English China Clay America Inc., Sandersville, Georgia, where analytical testing revealed a nondesirable sample for the filler industry due to poor colour quality (Table 11).

There is low potential for local kaolin in the filler industry, because of low tonnages and probable high beneficiation costs to bring the clay up to filler grade standard. The kaolin is being tested, through Nova Scotia Sand and Gravel, for its potential in other end uses such as ceramics. Test results are unavailable.

Two other locations in the Province have been investigated for their kaolin potential. The East Kemptville Tin Mine, Yarmouth County, and Chegoggin Point-Lake George area, Yarmouth County, are both primary deposits (Fig. 6). At the East Kemptville Tin Mine kaolin, in the form of altered feldspar and mica, occurs in the granites. A reconnaissance survey of the quarry and the tailings pond did not uncover any quantity that could be recovered economically.

A section of drill core from a recent diamond drilling program by the Nova Scotia Department of Mines and Energy (MacDonald, in preparation (b)) in the Chegoggin Point-Lake George quartzite unit (White Rock Formation) was sampled. The drillhole, CH-LG-87-6, contained a 1.93 m clayey section at 69.2 m which had an off white-buff colour. This was sampled in 0.46 m, 0.61 m and 0.91 m sections. The analyses from the top section returned high iron, therefore it is probably siderite or clay ironstone. The remaining sections are quite possibly just rock flour. This is probably a fault zone with very minor kaolin (Table 12).

Table 10. Hardwood Lands (West Indian Road), Hants County, kaolin clay content.*

Sample	Clay %	Silt/Sand %	Results of Analysis on Clay Fraction SiO_2 %	Al_2O_3 %	Fe_2O_3 %	K_2O %	Na_2O %	CaO %	MgO %	LOI %
Clay	81.3	18.7	47.59	35.20	1.42	1.82	2.67	0.11	0.23	9.89
Settling Pond	37.0	63.0	48.66	30.66	2.57	1.70	4.34	0.28	0.36	9.51

* Technical University of Nova Scotia, Halifax

Table 11. Analytical results for Hardwood Lands (West Indian Road), Hants County, kaolin*

CRUDE PROPERTIES

Brightness

Crude	63.6%
Waterwashed	65.5%
Waterwashed & bleached	66.4%
TiO_2 content	0.89%
Fe_2O_3 content	1.37%

Particle Size Analysis
Passing Through Sieve Dimension

10 μm	91%
5 μm	75%
2 μm	50%
1 μm	38%
0.5 μm	28%
0.25 μm	18%
Residue +325 mesh	6.4%

* English China Clay America Inc., Sandersville, Georgia.

Markets exist in Maine for paper grade kaolin filler, but local deposits are probably too small and impure. The high beneficiation costs for filler grade kaolin and the presence of the long established operations in Georgia, would make competition very difficult.

MUSCOVITE

Muscovite is a very common mineral occurring in siliceous igneous rocks, especially characteristic of pegmatites and also in various grades of metamorphic rock. Crystals can measure from a few microns to over 2.1 m across depending upon rock type and conditions prevalent during formation.

Table 12. Analysis of clay sample from DDH CH-LG-87-6 (percentage by weight), Chegoggin Point-Lake George, Yarmouth County

	DDH 87-6-46 69.2-69.8 m	DDH 87-6-45 69.8-70.7 m	DDH 87-6-30 70.7-71.1 m
SiO_2	18.91	28.20	41.70
Al_2O_3	11.92	18.47	30.98
Fe_2O_3	40.57	24.31	4.84
CaO	1.02	1.33	0.68
MgO	1.79	3.40	2.94
K_2O	0.64	0.71	1.38
Na_2O	0.04	0.04	0.09
LOI	20.59	16.48	11.02

* Technical University of Nova Scotia, Halifax

Muscovite is the most desirable mineral of the mica group for industrial consumption because of its neutral colour. Pegmatite deposits are of the most commercial interest. These can range from large sheet size muscovite crystals which are processed as sheet mica for use in the electronics industry to much smaller size muscovite crystals ground up for use as scrap and filler mica.

Sheet mica production is dominated by third world countries, India being the largest producer. Low labour costs play a major role in economically competitive sheet mica production because the mica must be quarried, split and trimmed manually with care not to damage the sheet itself. Demand for sheet mica is presently diminishing because of technological advancements in electronics phasing out many of the roles played by mica. This reduced demand causes more difficulties for potential North American developers competing with low cost Indian products.

North Carolina is the largest mica producing state in America (Chapman, 1983). Pegmatite of the Blue Ridge Mountains is quarried for virtually all its mineral constituents such as feldspar, silica, spodumene as well as muscovite. Generally large runs of book mica in

these commercially mined pegmatites make up as little as 2-6% of the rock.

Mica receives very little competition as a filler in most applications because of its unique platy structure and excellent dielectric properties. These two characteristics make muscovite an excellent filler for plastics. C. H. Kline and Associates (1986) have forecast a five year growth of 24.8% per year for mica consumption in the plastics industry.

Both surface treated muscovite and nontreated muscovite as well as phlogopite are included in this figure. Besides its use in the filler/extender industry (Fig. 10), mica also is used in well drilling muds, roofing shingles and in mica electrical insulating paper.

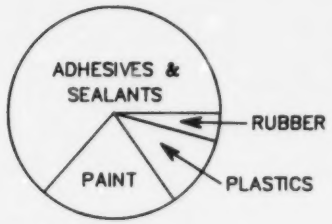


Figure 10. 1985 North American consumption of mica (Total = 109 588.5 t)

Local Resources

In Nova Scotia, three muscovite occurrences were investigated, each present in a different rock type and each with its own unique characteristics (Table 13).

Table 13. Location and rock type of three muscovite occurrences in Nova Scotia.

Location	Rock Type
Port Mouton, Queens County	muscovite in pegmatite veins
Mica Hill, Victoria County	muscovite in pegmatite dyke
Dingwall, Victoria County	muscovite/biotite in schist

Port Mouton, Queens County

Areas in Nova Scotia with abundant pegmatite veins are few (Kontak and MacDonald, personal communication, 1987) and those that do have high numbers of pegmatite dykes locally are probably not of any economic significance.

One of these areas, Port Mouton was visited in July 1987 (Fig. 6). Port Mouton is approximately 6 km southwest of Liverpool on Highway 103 to Yarmouth. Along the shoreline is a concentration of pegmatites, but these are at maximum 0.6-0.9 m in width and not continuous. The muscovite content of these pegmatites is approximately 5-10%, but the pegmatite concentration and thicknesses do not appear to be economically viable.

Mica Hill, Victoria County

Nova Scotia's best muscovite deposit occurs in the Cape Breton Highlands at Mica Hill which is approximately 10 km south of Dingwall (Fig. 6). This deposit is a zoned pegmatite with large flake muscovite occurring in a pink feldspar zone. The bulk of the pegmatite dyke is pure white bull quartz. The dyke has an approximate width of 30 m and is exposed along strike for over 100 m. The trend of the dyke is essentially east-west. There is also more large bull quartz on the small knoll immediately to the north which may indicate another zoned pegmatite.

The only literature found on the occurrence is by Fletcher *in* Young (1919) who noted that several test pits had been sunk into the hill though the exact date and results of this testing are not known.

Muscovite samples from Mica Hill were collected in July 1987. Approximately 4.5 kg were sent to the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada, Ottawa, for analysis (Appendix 1). The samples were crushed and sized. Results showed the muscovite to be high quality and with good industrial potential. Samples from Mica Hill were also examined at Magstone Development Inc. laboratory in Debert, Nova Scotia (Appendix 1). These samples were finely ground with extremely good results indicating filler grade mica.

Further exploration at the site is not possible at the present time because it is situated 4 km within the Cape Breton National Park and the present policy of the Park is that all minerals are nonextractable.

Dingwall, Victoria County

A muscovite/biotite schist was briefly examined in an aggregate quarry approximately 2 km east of South Harbour in Victoria County in July 1987. Blasting and quarrying of a pegmatitic granite revealed a flaky schist. The schist has not been traced for any length because of overburden. Samples were taken and an ensuing thin section analysis revealed the main constituents of the rock to be quartz, muscovite and biotite. The surface in contact with the pegmatite is much flakier (possibly due to weathering) than the bulk of the unit and a thin section could not be made of it. A sample was crushed manually though and revealed under microscope a composition of 90-100% mica, with approximately equal parts of muscovite and biotite. Through the schist, which is about 1 m thick, the quartz content increases to

a maximum of 50%. A point count was administered on a thin section of a sample extracted near the bottom of the section. A 500 point total revealed 22% muscovite, 21% biotite and 48% quartz. The other 9% was minor constituents, predominantly garnet. The average grain size was in the 3-4 mm size range.

More detailed examination of this occurrence would be worthwhile because the muscovite could be easily separated from the biotite using magnetic separation and is already at a workable grain size, requiring only fine grinding. The location is within 10 km of deep water at Dingwall and is also nearby the Mica Hill muscovite deposit.

Other Sources

The andalusite/garnet schist at Doughboy Point, Guysborough County, may be another source of filler grade muscovite. If this stone were to be processed as a source of aluminum, the fine grained muscovite present might be separated for market consumption. This property was staked by private interests and was inaccessible to Departmental employees.

Finally, a bag sample of the fines from the East Kemptville Tin Mine tailings pond was recovered for examination for its mica content. A microscope analysis revealed the muscovite content to be minor and have no apparent economic potential.

Muscovite appears to have a great future in the filler industry. Two local sources, Mica Hill and Dingwall, may have potential for such applications. There may be other muscovite sources in Nova Scotia that have been overlooked during the field study.

GROUND SILICA

Quartz is one of the most widely distributed minerals in the world and is the source mineral for the ground silica used in various industries. It occurs in both igneous and metamorphic rocks and is abundant in clastic sediments. High purity sources are not quite as prevalent though, especially those where the quartz is easily ground and separated from other constituents. The major source of ground silica in the filler industry is from friable rock or from natural high grade sands. Rarely do sands approach a level of pure silica quality which would require a minimum of beneficiation for commercial use.

Ground silica's major problem as a general bulk filler is its high abrasiveness. In some applications this can be advantageous, for example increased scrubability in certain grades of paint (Fig. 11). Generally the wear on machinery silica causes during processing of an end product is undesirable.

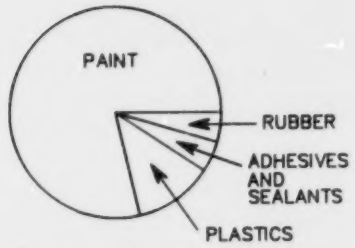


Figure 11. 1985 North American consumption of ground silica (Total = 134 718 t)

Local Resources

Silica sand deposits and sandstones in Nova Scotia are not thought to be of sufficiently high grade for filler use. With a very small local market for filler silica and no indications of a major need in the New England region, any local source that would have to undergo beneficiation might not be feasible to produce.

One opportunity that may exist though is in the White Rock Formation quartzites, most notably the high purity Chegoggin Point to Lake George band in Yarmouth County (Fig. 6). This bed of silica consistently registers over 99% SiO_2 and, if quarried in the future, the fines may be acceptable as filler product. This deposit was drilled in the late summer and fall of 1987 by the Nova Scotia Department of Mines and Energy (MacDonald, in preparation (b)).

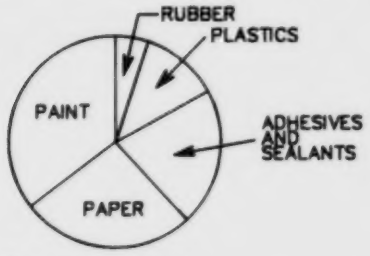
TALC

Talc usually occurs as a secondary mineral, the result of alteration or hydration of magnesium silicate rocks or it can be found occurring in metamorphosed dolomites. Most economically important deposits have been formed under low grade regional metamorphism.

Its platy particle shape, high oil absorption and high degree of brightness make it a valuable filler. Along with having a major share of the filler market, talc is also consumed in large amounts in both the ceramics and cosmetics industries (Fig. 12).

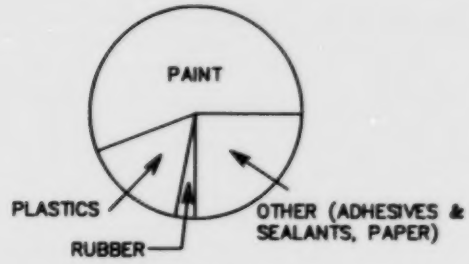
Local Resources

Talc, known in its massive form as soapstone, has been identified in such places as Soapstone Brook, Victoria County, and Soapstone Mine, Inverness County (Fig. 6). These occurrences are impure and minor. A higher grade of talc has been noted at depth in the old Stirling Mine, Richmond County. Its economic potential has yet to be determined.



Based on Figures From C.H. Kline and Associates (1986)

Figure 12. 1985 North American consumption of talc (Total = 452 688 t)



Based on Figures From C.H. Kline and Associates (1986)

Figure 13. 1985 North American consumption of titanium dioxide (Total = 901 747 t)

Because there are only very minor occurrences of talc in the Province and the quality is poor, little time was spent investigating the mineral. More information on talc in Nova Scotia can be obtained from MacDonald (in preparation (a)).

TITANIUM DIOXIDE

The mineral ilmenite ($FeTiO_3$) is the source for over 90% of the world's supply of titanium dioxide pigment production. Plutonic rocks are the principal host for ilmenite, but a considerable amount is recovered in placer mining operations from beach sands. Commonly, beneficiated ilmenite is referred to as synthetic rutile.

Natural rutile and its polymorph anatase are other important forms of titanium, but do not play as large a role in the pigment market as ilmenite. Rutile is more expensive and finds its major end use in titanium metal.

Titanium dioxide pigment is unchallenged as a surface coater in the paper, paint and plastics industries (Fig. 13). Its high refractive index, which allows it to impart unparalleled degrees of whiteness, opacity and brightness to all end products, finds competition only in some forms of silica, alumina hydrate and calcined kaolin. Competition is either a result of demand for TiO_2 being greater than supply or of the high cost of titanium dioxide relative to other pigments.

Local Resources

In Nova Scotia, placer deposits in the form of beach sands constitute the major source of titanium which could be investigated for quality and quantity. Two locations have been noted to have quite dark sands which could be titanium rich. One of these locations is on Sable Island which, due to government restrictions, makes investigation of the sand units impossible.

More accessible are the dark sands of the Shubenacadie River (Fig. 6). Initial investigations were performed by MacDonald (1989) in November 1986 and a subsequent testing of samples recovered in April 1987. The samples were taken at the Gosse Bridge near South Maitland and assayed over 20% TiO_2. Although the unit or layer of dark sands on the surface is not thick (7.6 cm), MacDonald (1989) suggested more detailed and systematic sampling be carried out to locate possible areas of high concentration and to determine whether or not these lenses repeat themselves throughout the sand deposit.

Titanium dioxide is in great demand in the industrial world. Operations producing TiO_2 pigment are large scale because beneficiation of the raw ore to a pigment end product is very detailed and expensive. It is questionable whether or not the sands of the Shubenacadie River could support such an operation, in quantity and environmental conservation is a concern.

WOLLASTONITE

Wollastonite is a new industrial mineral as far as consumption and use are concerned, dating back to 1949 when an industrial plant was built in New York State to manufacture wollastonite products.

This calcium metasilicate ($CaSiO_3$) occurs as a contact metamorphic deposit formed between limestone and igneous rock or in silicated metalimestone that has been affected by regional metamorphism. Deposits of economic size and purity are rare.

There are very few wollastonite producers in the world, the largest being NYCO, a division of Processed Minerals Inc., working the Fox Knoll Mine near Willsboro, New York State.

The largest consumption of wollastonite is as a filler and extender. Its acicular shape, chemical inertness and high brightness make it ideal for the plastics industry (Fig. 14). Since quality deposits of wollastonite are rare, the mineral does not play a major role in the filler

industry. Because of its characteristics, demand will always meet supply and, for this reason, investigation of Nova Scotia's wollastonite occurrences is worthwhile.

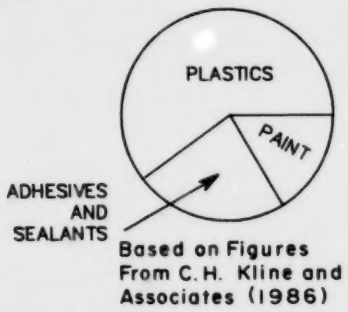


Figure 14. 1985 North American consumption of wollastonite (Total = 40 823.5 t)

Local Resources

Wollastonite has been identified both in drill core and in outcrop at Lime Hill, Inverness County (Fig. 6). This George River Group hosted occurrence does not have the in situ purity of the New York State deposits, but recent analysis by the Canadian Centre for Mineral and Energy Technology, Ottawa, indicated that with further processing acceptable grades could be reached.

These grade standards include an Fe_2O_3 content of <0.2%, a brightness in the 90% range and a concentrate of at least 90% $CaSiO_3$. Whether or not these grades can be attained economically is unknown.

The Lime Hill deposit is part of the band of George River Group metasedimentary rocks stretching along the southeastern slope of North Mountain on the West Bay coast of the Bras d'Or Lakes in Inverness County. This band of highly altered and mineralized limestone is an attractive possibility for occurrences of wollastonite. Exploration in the area may reveal similar occurrences to the Lime Hill showing.

Unfortunately time restricted this type of exploration. The Lime Hill occurrence was inaccessible to Departmental investigation because the area has been staked by private interests.

GROUND CALCIUM CARBONATE

Limestone and its metamorphosed equivalent marble are North America's major source of calcium carbonate and also two of the earth's most common mineral commodities.

In terms of total consumption, ground calcium carbonate is the second most important mineral in the filler industry. This can be attributed to its widespread availability, low beneficiation cost, high brightness (brightness is a measure of the total percentage of light reflected from a sample in comparison with a theoretical (100%) or physical standard), low abrasiveness, functional particle shape and low overall production cost.

Because of the abundance of limestone and marble deposits in the world, purity, tonnage and accessibility to market are some of the determining factors in deciding whether or not a deposit has economic potential in the filler industry.

Desirable grades vary depending upon end use (Fig. 15). In the paper industry, standards require a high brightness reading in the range of 95%+, a $CaCO_3$ content of approximately 98% and a mean particle size in the range of 1 μm. Ground calcium carbonate to be used in the carpet backing industry, however, does not require such a high brightness reading (approximately 90%), a $CaCO_3$ content only in the 94% range and a mean particle size in the 20-30 μm range. For obvious reasons prices vary greatly depending upon end use because of increased or decreased beneficiation costs.

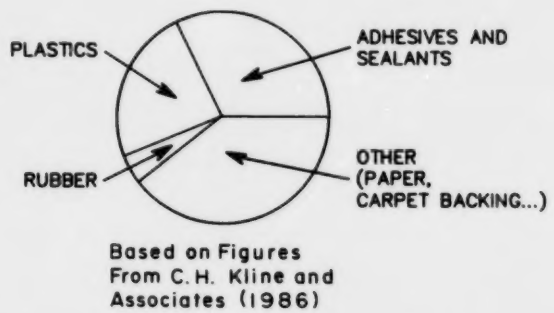


Figure 15. 1985 North American consumption of ground calcium carbonate (Total = 2 783 259 t)

Local Resources

In Nova Scotia, the major limestone/marble deposits belong to either the Carboniferous Windsor Group or the Hadrynian George River Group of Cape Breton Island. Windsor limestone tends to be fossiliferous and lower grade than the George River marbles so investigations focused on the George River stone. Metamorphism of the George River carbonates effectively cleaned the stone in many areas of its organic constituents. Two locations in particular, Glencoe and Marble Mountain, Inverness County, received the majority of attention (Fig. 6). Previous drilling had shown that there were some high grade zones occurring in the Glencoe area. Marble Mountain was chosen because of its high grade stone potential beneath the quarry floor.

In the field investigation a limestone/marble with a white to off white colour was desirable with a subsequent chemical analysis of high calcium, low magnesium, silica and alumina, and trace quantities of all other elements. Dolomitic stone is less desirable by industry because of the increased hardness and abrasion on machinery. The same also holds true for a high silica content.

Proximity to market is an essential factor to consider. The cost savings in transportation rates could outweigh less desirable attributes such as higher grinding costs. Dolomite is available at Cape Dauphin which could find a place in the markets because of its reduced handling and transportation costs.

Glencoe Limestone Deposit

Introduction

The Glencoe limestone deposit is located in Inverness County, Cape Breton Island. The deposit was sampled and mapped by Murray and Shea (1969), Milligan (1970), Scotia Limestone (MacNeil, 1974) and studied extensively by MacNeil (1972). Drilling in 1974 by Scotia Limestone consisted of 19 holes for a total of 2004 m of core recovered (MacNeil, 1974). The deposit was drilled again in 1975-76 and 1976-77 (MacNeil, 1977).

This extensive drilling program was initiated by the Nova Scotia Department of Mines and Energy and the Canada Department of Regional Economic Expansion in 1975 (MacNeil, 1977). By the completion of the 1975-76 and the 1976-77 programs a total of 85 holes were drilled and 12 347 m of core recovered. This drilling was accomplished using a fence pattern with each panel spaced 609.6 m apart following the dogleg shape of the deposit. The 1976-77 program provided infilling. Drillhole spacing along each panel was 122 m and each hole was drilled at a 45° angle into the dipping limestone beds up to a maximum of 167.64 m in length. These programs indicated reserves for cement grade limestone of 163.3 million t and metallurgical limestone of approximately 190.5 million t.

The crystalline Glencoe limestone is found in a variety of colours and chemical grades, ranging from pure white to reddish to grey black. The stone can also be found as pure as 98% $CaCO_3$.

Glencoe Drill Core Analyses

The drilling information and core from the 1975-77 Glencoe diamond drilling program was reviewed (MacNeil, 1977). Because of the variety in impurities in the limestone much of the chemically high grade stone was not white in appearance, but had a blue or grey hue. Some appeared graphitic. Fifteen crushed samples, each representative of a 3 m drillhole section, were retrieved from the Nova Scotia Department of Mines and Energy warehouse in Debert. These were chosen based upon their high chemical purity.

Many of the samples chosen were graphitic and a froth flotation test was used to remove as much graphite and free silica as possible. A brightness test before and after flotation was done to reveal the degree of success (Appendix 1).

The silica decreased in total percentage after the flotation. The magnesium, tied up in the chemical compound $MgCO_3$, was not really affected. Brightness generally improved after the flotation, but not drastically. Another method would have to be designed to successfully remove the graphite economically and have a clean product.

Field Sampling

Sampling during Spring 1987 was to help delineate an area of high purity limestone to be drilled at close space to prove a tonnage figure for potential filler grade limestone. Samples were gathered either on the basis of whiteness of outcrop or on surface projection of quality stone identified in previous drilling programs. Forty-two samples were collected and analyzed (Fig. 16; Table 14).

One area, in particular, provided both good colour and high $CaCO_3$ values. A bulk sample was taken using an excavator in the fall of 1987. Stripping of the overburden revealed an extensive section of quality white stone with some minor staining throughout. Random analysis from the pit, which is located in the vicinity of RS8 (Fig. 16), revealed that the grade of stone was acceptable for consumption in some filler markets. This area of filler grade stone appears to be only one of many such zones found at Glencoe (MacNeil, 1977). Some of this sample was taken to Magstone, Debert, for cleaning and fine grinding and to Tibbetts Paint Company, Trenton, for testing in paint samples.

Tibbetts Paint Company Limestone Testing

One of the major consumers of filler minerals in the Atlantic region is Tibbetts Paint Company, Trenton, Pictou County, Nova Scotia. Calcium carbonate is used in large quantities for many of the paint products and in particular for their highway grade coater. Over 400 t annually of Snowhite 452, from Steep Rock Calcite Company, Perth, Ontario, is added to this paint mixture. This is the largest single product used by the Tibbetts Paint Company.

Thirty pounds of carbonate from the bulk sample pit was finely ground to three different micron sizes at Magstone Development Ltd., Debert, Colchester County. Three samples were ground wet, and the fourth was ground in varsol which is a solvent used in the highway paint. The three wet ground samples were pulverized and then micronized in a paddle mill, test 44 for

Table 14. Results from Glencoe limestone deposit, Inverness County field sampling. See Figure 16 for sample locations.*

Sample No.	CaO %	MgO %	SiO_2 %	Al_2O_3 %	Brightness (Photovolt)
RS- 1	49.38	2.08	2.10	1.30	70.3
RS- 2	51.82	1.32	2.17	0.64	84.3
RS- 3	54.34	0.59	0.44	0.13	66.5
RS- 4	48.37	5.92	0.55	0.14	87.2
RS- 5	55.10	0.39	0.57	0.18	75.8
RS- 6	55.44	0.33	0.33	0.18	79.1
RS- 7	54.85	0.70	0.29	0.27	80.5
RS- 8	53.67	0.44	0.47	0.23	87.2
RS- 9	52.91	0.33	0.59	0.24	74.9
RS-10	53.33	0.11	0.42	0.07	91.1
RS-11	55.35	0.24	0.71	0.26	61.3
RS-12	55.35	0.36	0.42	0.21	73.9
RS-13	55.52	0.35	0.42	0.14	80.7
RS-14	54.76	0.77	0.38	0.06	72.9
RS-15	52.49	2.97	0.42	0.14	71.9
RS-16	55.01	0.29	0.78	0.14	74.2
RS-17	54.01	0.43	0.30	0.27	72.8
RS-18	55.27	0.56	0.76	0.29	78.1
RS-19	54.34	0.34	0.37	0.07	80.5
RS-20	42.56	0.56	19.79	0.58	61.1
RS-21	47.44	0.58	13.59	0.18	59.2
RS-22	53.00	0.66	1.85	0.28	81.1
RS-23	53.75	0.54	0.69	0.25	92.9
RS-24	50.47	0.74	6.37	1.37	56.0
RS-25	48.87	4.24	5.95	0.72	85.9
RS-26	49.04	2.52	7.58	2.49	80.6
RS-27	47.53	5.10	1.00	0.51	85.5
RS-28	49.46	1.89	5.73	0.86	87.0
RS-29	52.74	1.19	1.20	0.95	83.7
RS-30	44.08	2.63	11.27	2.71	76.4
RS-31	41.47	12.03	0.65	0.57	77.2
RS-32	51.40	3.03	0.77	0.85	84.4
RS-33	46.60	7.38	0.79	0.43	74.2
RS-34	46.60	5.65	1.64	1.29	72.8
RS-35	48.62	5.94	1.66	0.73	83.4
RS-36	46.77	7.70	0.74	0.21	80.7
RS-37	54.34	0.25	0.37	0.22	50.6
RS-38	54.51	0.39	0.74	0.29	51.2
RS-39	54.34	0.81	0.53	0.18	49.9
RS-40	55.01	0.51	0.45	0.26	50.5
RS-41	55.01	0.57	0.41	0.09	88.4
RS-42	38.70	14.94	0.57	0.16	73.4

* Minerals Engineering Centre, Technical University of Nova Scotia, Halifax, July 1987

5 minutes, test 54 for 10 minutes and test 65 for 15 minutes. A mean micron size analysis test was not performed, but Mr. Dennis Stone who ran the grinding test estimated that sample 44 was in the 12-16 μm size, test 54 in the 6-10 μm range and test 65 approximately 2 μm.

The samples were analyzed at the Technical University of Nova Scotia for chemical purity and brightness (Table 15).

Fred Hughes, assistant chemist at Tibbetts, reported that the Glencoe limestone would make an acceptable substitute for the Snowhite 452 (Appendix 1).

If the Glencoe stone is acceptable for Tibbetts product line, it probably could be used by the other three paint producers in the Atlantic region.

Table 15. Chemical analysis and brightness for samples from Glencoe, Inverness County.*

Test No.	CaO %	SiO_2 %	Al_2O_3 %	MgO %	Brightness (Photovolt)
44	53.28	1.56	0.92	0.62	85.4
54	53.64	1.12	1.14	0.51	91.0
65	53.21	0.96	0.91	0.50	91.6
75 [varsol]	52.15	1.13	1.46	0.53	87.8

* analyses by Minerals Engineering Centre, Technical University of Nova Scotia, Halifax

Glencoe 3-Dimensional Model

A scale model of the Glencoe deposit was designed and constructed out of plexiglass and wood at the Nova Scotia Science Museum from data from the drilling programs carried out in the seventies. This model delineates zones of various limestone grades in the deposit on plexiglass cross-sectional panels. The limestone quality separations (metallurgical, cement, filler grades) are based upon chemical criteria. The model can be viewed at the Industrial Minerals Section of the Nova Scotia Department of Mines and Energy's head office in Halifax.

Computerization of Assay Values

In the past year all of the chemical assays for the 1975-76 and 1976-77 drilling programs were entered into a data base that can be accessed through the Engineering Section at the Nova Scotia Department of Mines and Energy. A program was devised to pick out sections of the drill core encompassed by a preset

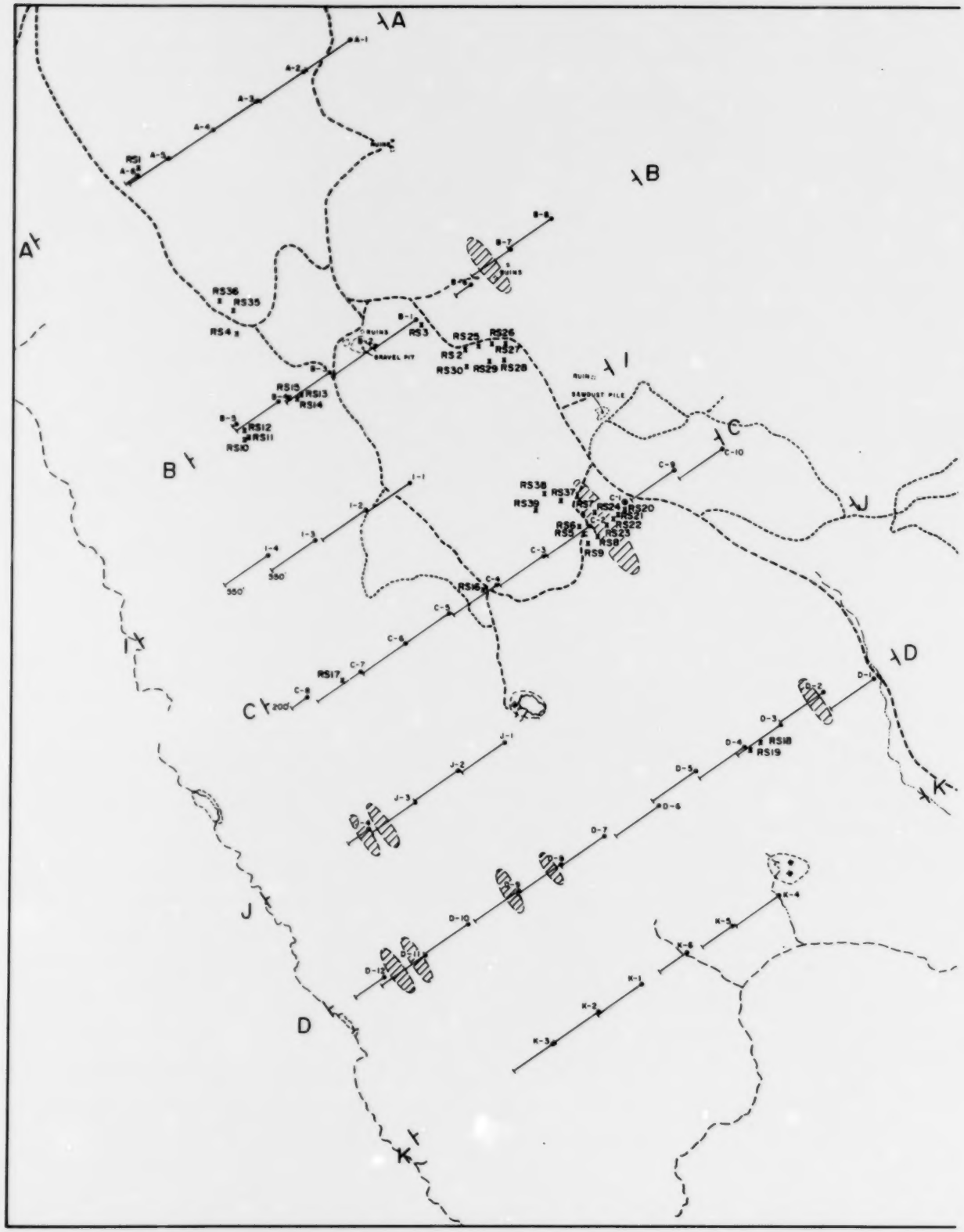


Figure 16. Location map of samples collected and analyzed, Glencoe limestone deposit, Inverness County

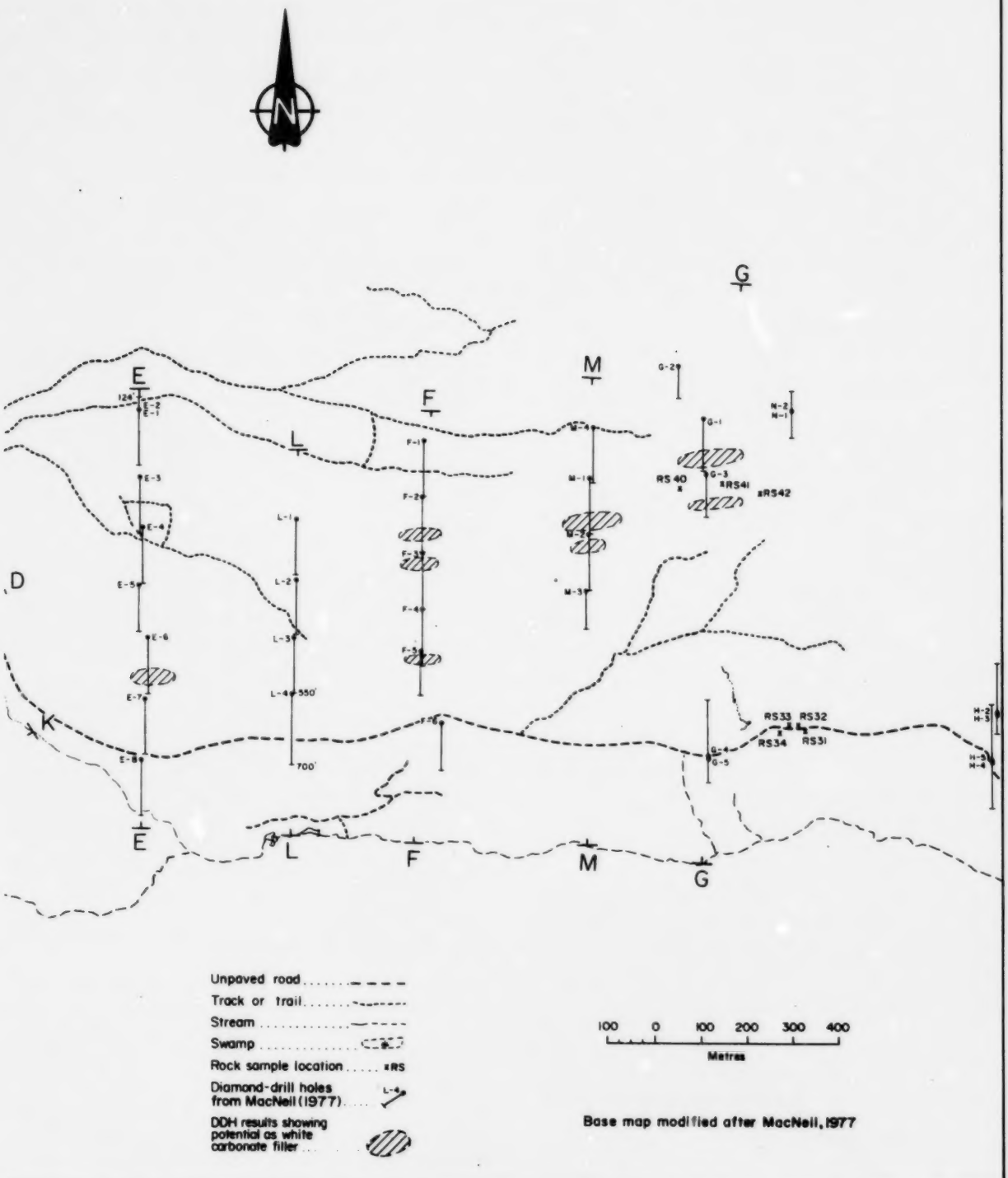


Figure 16. Continued

number of chemical values i.e. CaO >50%, MgO <2%, SiO_2 <2%. This can prove valuable and time saving when keying in on zones of similar grade stone.

Marble Mountain Quarry

Introduction

The Marble Mountain limestone deposit is part of a band of George River Group metasedimentary rocks which stretch along the southeastern slope of North Mountain on the West Bay coast of the Bras d'Or Lakes, Inverness County.

The quarry at Marble Mountain was operated from 1886 until the early 1920s. Besides the main quarry which was operated on three separate benches, there is also a second smaller quarry directly to the north which contains fairly dolomitic stone. The majority of stone was used as burned lime and for blast furnace flux. Quarrying ceased due to intolerable levels of magnesia and contractual problems with the lease.

Geology

The Marble Mountain deposit is typical of many of the George River Group limestone bodies. Beds are difficult to trace, colours vary throughout the deposit, and chemical values are erratic ranging from very pure marble to low quality in terms of magnesia and silica values.

Alterations and mineralization due to the intrusions of granitic bodies are very prevalent. In the old quarry serpentinization, as well as mineralization in the form of trace pyrrhotite, pyrite and galena, can be found.

The deposit was mapped by Milligan (1967) as a synclinal structure plunging almost 50° along a 220° strike.

Previous Work

After over 40 years of inactivity, Marble Mountain was drilled in 1965 by the Provincial government. A total of 4 holes and 162 m of recovered core gave little indication of the potential of any marble remaining under the quarry floor. Subsequent mapping and sampling by Milligan (1967) showed a variety of marble with regard to colour and chemical constituents. Milligan (1967) felt there could be high grade stone still available beneath the quarry floor.

The only activity ongoing in the quarry has been the extraction of minor amounts of white marble by Nova Scotia Sand and Gravel for use as marble chips.

Current Investigation

Random sampling by the author during Spring 1987 of some of the whiter stone and subsequent analytical testing confirmed both Milligan's (1967) and MacNeil's (1977) acknowledgments of high quality stone still in the quarry (Table 16).

Table 16. Random and chip samples from Marble Mountain quarry, Inverness County*

Sample	Interval m	CaO %	MgO %	SiO_2 %	Al_2O_3 %
RS-MM-1		54.17	0.48	1.5	1.18
Chip Sample	0-3	54.85	0.63	0.44	0.21
Chip Sample	3-6	52.83	3.08	0.60	0.38
Chip Sample	6-7.6	47.97	5.18	1.53	1.0

* analyses by Minerals Engineering Centre, Technical University of Nova Scotia, Halifax

This initial sampling and subsequent literature review of the area was followed up with a chip sample taken across the section of white stone on bench number 2 that is quarried by Nova Scotia Sand and Gravel. Analyses (Table 16) show excellent chemical results for the first 3 m and then an increase in the magnesium content for the remaining 4.6 m.

Samples from Marble Mountain and Glencoe were sent to English China Clay American, Georgia, for analysis. The results for Marble Mountain in particular were very promising, showing a high brightness reading and low magnesium and insoluble values (Table 17). These results compare favourably with many products in the filler industry.

Four holes were drilled in the early 1960s, but only one drillhole was collared in a location that seemed highly likely to intersect quality stone. The core from the Nova Scotia Department of Mines and Energy office in Stellarton was split and reanalyzed at the Technical University of Nova Scotia, Halifax. The results for hole 2 show some zones of high purity white limestone (Appendices 2 and 3). Five more holes were drilled in January 1988 to intersect this same quality stone and delineate a rough tonnage.

Marble Mountain Drilling Program

A diamond drilling program for the Marble Mountain quarry was initiated in January 1988 (Fig. 17). The five drillhole locations and angles were based upon Milligan's (1967) structural interpretation of the quarry. Milligan (1967) described the quarry as a synclinal structure plunging approximately 50° along a 220° strike. Based on this, MM-88-1 was collared in a location which approximated the axis of the syncline and drilled on a 45° angle in a 030° direction into the plunging syncline. Core recovered was 91.44 m. Results from this hole

Table 17. Analytical results from Marble Mountain and Glencoe limestones.*

Sample	Brightness[1]	$CaCO_3$[2] Wt%	Insolubles Wt%	$MgCO_3$ %
Marble Mountain				
Coarse Ground[3]	93.2	96.62	2.64	0.74
Floated & Fine Ground[4]	97.1	97.48	1.89	0.63
Glencoe				
Coarse Ground[3]	84.5	95.56	2.50	1.94
Floated & Fine Ground[4]	93.8	97.85	1.61	0.54

* analyses by English China Clay American, Georgia
[1] Elrepho - AACC
[2] By EDTA method - some evidence of Fe interference
[3] Approximately 50% retained on 325 mesh screen and 10% on a 100 mesh screen
[4] ACC float ground by sand grinder to 91% <2 μm

were very promising and revealed a considerable section of high brightness marble of fairly consistent colour and chemical purity. Drillholes MM-88-3 and MM-88-5 were collared along the same strike (030°) as MM-88-1 and revealed thicknesses of the whiter units with chemical consistency along strike.

MM-88-2 and MM-88-4 were both drilled on the limbs of the syncline. MM-88-2 was drilled on the eastern limb to a depth of 55.78 m. It was hoped to drill 60+ m deeper, but due to swelling in the core barrel from clay which had infiltrated the many fractures in the marble, drilling was slow and time restraints meant this was not possible. MM-88-4, on the western limb of the syncline, was drilled at a 45° dip with a bearing of 310°. It encountered various colour grades of marble including a thin band (~8 m) of light grey-white stone. This is probably the same band that is exposed along the high western wall of the quarry and that is also intersected on the other side of the quarry in MM-88-2.

Rough tonnage estimates based on drill results show that there could be up to 900 000 t of high purity white-off white marble in the Marble Mountain quarry. Extraction of this stone would not be difficult and facilities for shipping could be made at the base of the quarry. Trucking or rail may also be options.

More exploratory work on the quarry would further delineate the high purity zone. Trenching across the northeastern end of the quarry perpendicular to the strike of the syncline would reveal the extent of the zone by channel or chip sampling the length of the trench.

Summary of Nova Scotia Calcium Carbonate Resources

The Glencoe limestone is a good quality material probably best suited for carpet backing and road paints because of its slightly low brightness values. The staining of the minor fractures and veinlets lower the colour grade dramatically. Our work encompassed just one small area of this massive deposit so there could be more zones present of even better quality stone.

The carpet backing and road paint industries in Nova Scotia alone use at least 1.7 thousand t of this quality of limestone annually. Beneficiation costs for such a product would be minimal. The Glencoe deposit is <20 km away from railway transportation and the consumers are on rail lines.

Marble Mountain appears to be a higher quality stone with vast potential in the filler industry. High brightness, chemical purity, large tonnage and convenient location near water transport make it a prime development property.

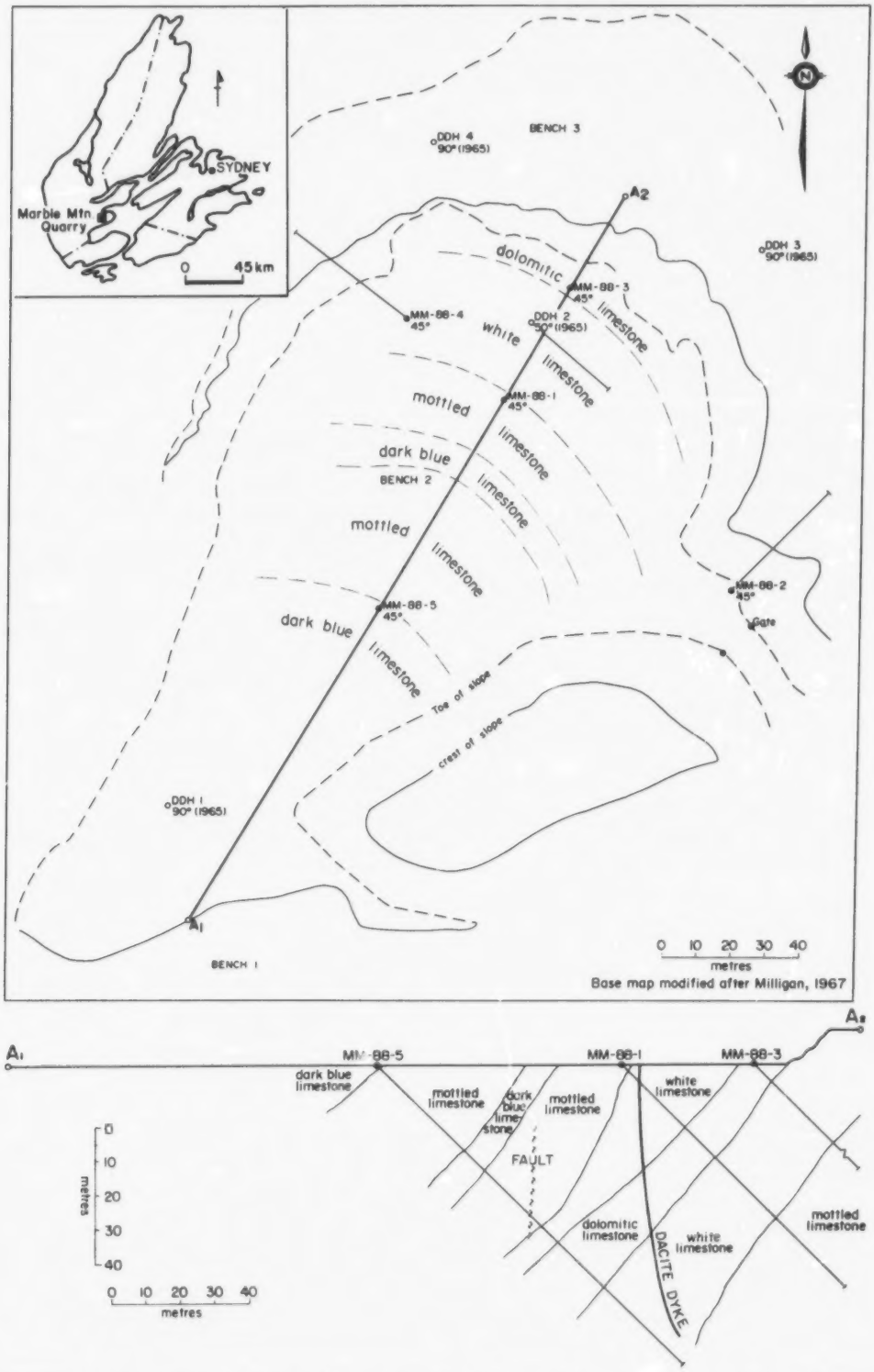


Figure 17. Drillhole location map and cross-section of the Marble Mountain quarry, Inverness County

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APPENDIX 1. LIMESTONE FILLER SPECIFICATIONS LABORATORY REPORTS

Energy, Mines and Resources Canada (mica)
Magstone Development Inc. (mica)
Technical University of Nova Scotia (limestone)
Tibbetts Paint ($CaCO_3$)

LIMESTONE FILLER SPECIFICATIONS

PULVERIZED LIMESTONE ASSOCIATION STANDARD

A - 1a

Type -325 Mesh High Calcium Limestone

+325 Mesh	0.57%		Method 1A - 67T
pH	9.45		Method 2 - 65
Particle Size		Method 3A - 73 (Hydrometer)	Method 3B - 82 (Sedigraph)
Finer than	30 μ	95.7%	96%
	25 μ	-	91%
	20 μ	76.0%	82%
	15 μ	65.0%	70%
	10 μ	51.0%	54%
	8 μ	-	45%
	5 μ	30.0%	32%
	2 μ	14.0%	13%
	1 μ	-	4%
Chemical Analysis		Method 4 - 70	
$CaCO_3$		95.11%	
$MgCO_3$		2.93%	
Dry Brightness		Method 5 - 82	
G	=	91.7%	
B	=	89.4%	
Fineness of Grind		2	Method 7 - 73T
Water Demand		38	Method 6 - 73

PULVERIZED LIMESTONE ASSOCIATION STANDARD

P - 1a

Type - Very Fine Ground High Calcium Limestone

+ 325 Mesh	<0.1%		Method 1A - 67T
pH	9.45		Method 2 - 65
Particle Size		Method 3A - 73 (Hydrometer)	Method 3B - 82 (Sedigraph)
Finer than	10 μ	96%	96%
	8 μ	90%	91%
	6 μ	80%	81%
	4 μ	66%	64%
	2 μ	40%	37%
	1 μ	-	18%
	0.5 μ	-	4%
Chemical Analysis		Method 4 - 70	
$CaCO_3$		96.71%	
$MgCO_3$		2.82%	
Dry Brightness		Method 5 - 82	
G	=	96.6%	
B	=	95.6%	
Fineness of Grind		6.0	Method 77 - 73T
Water Demand		47	Method 6 - 73

LABORATORY REPORTS

Energy, Mines and Resources Canada (mica)

Energy, Mines and
Resources Canada

Research and Technology

Canada Centre for Mineral
and Energy Technology,
555 Booth Street
Ottawa, Canada
K1A 0G1

Énergie, Mines et
Ressources Canada

Recherche et Technologie

Centre canadien de la technologie
des minéraux de l'énergie,
555, rue Booth,
Ottawa, Canada
K1A 0G1

August 19, 1987

Mr. Peter Luke
Nova Scotia Dept. of Mines and Energy
1701 Hollis Street
P. O. Box 1087
Halifax, N. S.
B3J 2X1

Dear Peter:

The two submitted samples of muscovite from Mica Hill were reduced in size by roll crusher and hammer mill, and screened at 1, 1/2, and 1/4 in. Results were as follows:

	Samples - Wt. %	
Size (in.)	87/19 A	87/19 B
+1	0	0
-1, +1/2	3.5	7.4
-1/2, +1/4	40.1	42.3
-1/4	56.4	50.3
	100.0	100.0

Products from both samples were similar:

- The -1, +1/2 in. size essentially consisted of 1 x 1 in. exfoliated sheets of mica and unexfoliated "slivers" ranging up to 1/2 x 3 in. in size; a few pieces were spotted with dark mineral specks as well as a reddish impurity.

- The -1/2, +1/4 in. fractions were generally similar to the above with flake size being 1/2 x 1/2 in. and the slivers ranging up to 1/2 x 2 in. size.

- The -1/4 in. fractions largely consisted of fine exfoliated flakes of mica with minor dark granular mineral impurity: this impurity could have been introduced during crushing in the hammer mill.

... /2

These two samples are exceptionally pure. Material of this purity would require minimal processing/beneficiation for many uses for flake and ground muscovite provided markets can be identified. However, you did note that this mica occurred in a pegmatite, in which case economic recovery, being dependent on both grade and association, could present a problem.

I expect to be in Halifax September 2-4 and would like, at that time, to further discuss this mica and possibly visit the deposit. In the meanwhile, the small enclosed sample fractions will be of interest.

Very truly yours,

R. K. Collings,
Non-Metallic Minerals

RKC/mv

cc: D. Doyle
P. Andrews
M. Grice, NSDME
J. Fowler, NSDME

Magstone Development Inc. (mica)

MAGSTONE DEVELOPMENT INC.

PLANT:
Unit No. 5, Debert Air Industrial Park
Debert, N. S. B0M 1G0
(902) 662-3222
Telex 019-34587

MAILING ADDRESS:
9 Fundy Drive, Truro
N.S. B2N 5Y2
(902) 893-7642

Nov 5/87

Mr. Peter Luke,
Dept. of Mines & Energy,
PO Box 1087
1690 Hollis Street,
Halifax, N. S. B3J 2X1

TREATMENT REPORT - MICA

Material		Mica from Cape Breton
Delivered		Peter Luke, Dept. of Mines, Nova Scotia
Type		Relatively large sheet
Treatment	a)	Crushed - with hand hammer to about -2" sheets
	b)	Ball Mill - ceramic ball mill screened on 8 mesh / / -8Mesh +8Mesh Hard pieces
	c)	Paddle Milled -8 Mesh Paddle Milled
	d)	Filtered & Dried - Buchner Filter
	d)	"Fluffed" - Pestle & Mortar Bulk density 0.495 gms/cc

Additional Tests

Leached HCl - -8mesh portion boiled 30 minutes with HCl. Acid turned yellow indicating that at least some iron removal occurred.

Comments: This very preliminary treatment indicates that a high grade mica product should be readily achievable. Visually it compares very favourable with a BC Mica on which Magstone conducted extensive work. A small content of "garnets" was observed.

Suggestion Apparently the Mica content of the deposit is not known. However, there is a use for high purity mica in the electronics field. It might be attractive to develop such a high grade product and produce for this market while the deposit is being evaluated for size for the conventional market.

Magstone would develop and produce.

It is understood that such a product sells for 8 to 12 dollars per pound. Magstone has the contact to explore the setting up of such a facility.

This is underway.

Sincerely,

W. J. D. Stone, President
Magstone Development Inc.

WJDS/kmc

Technical University of Nova Scotia (limestone)

MINERALS ENGINEERING CENTRE

Technical University of Nova Scotia
P. O. Box 1000 Halifax, N. S.
Canada B3J 2X4

Telephone (902) 429-8300
Telex (TUNS) 019-21566

15 January, 1988

Nova Scotia Dept. of Mines and Energy
P. O. Box 1087
Halifax, N. S.
B3J 2X1

Attention: P. Luke

RE: Results of silica flotations and analyses on submitted limestone samples.

For the flotations we used 125 or 250 grams of sample which was pulverized to 100% minus 325 mesh.

Reagent: 1 Rosin Amine D Acetate 50%

					Brightness	
		mls.	% Weight		As	After Si
Sample	Weight (gr)	Reagent	Conc(Si)	Tails($CaCO_3$)	Received	Flotation
A6-6-20	250	.10	9.3	90.7	77.3	78.3
B1-20-30	125	.05	27.8	72.2	53.0	55.9
B3-210-220	125	.05	18.1	81.9	73.7	77.8
B4-300-310	250	.10	20.6	79.4	91.0	93.7
C2-60-70	125	.05	20.2	79.8	83.8	83.7
C2-120-130	125	.05	29.0	71.0	42.0	44.1
C7-280-290	125	.05	21.7	78.3	73.9	76.2
D1-400-410	125	.05	24.3	75.7	90.7	92.4
D3-110-120	250	.15	28.7	71.3	44.2	53.5
D4-8-20	125	.075	19.1	80.9	49.2	52.5
D9-150-160	125	.05	32.1	67.9	79.6	80.9
D12-80-90	250	.10	26.5	73.5	89.4	92.2
F3-70-80	125	.05	27.3	72.7	71.0	72.7
G3-9-20	250	.10	12.2	87.8	83.4	83.8
J1-300-310	250	.10	19.3	80.7	89.6	90.2

... /2

Sample	As Received			After Si Flotation		
	CaO%	MgO%	SiO_2%	CaO%	MgO%	Sio_2%
A6-6-20	52.41	1.30	2.15	54.85	1.33	1.93
B1-20-30	53.67	0.60	2.00	54.17	0.67	1.73
B3-210-220	54.34	1.50	0.40	54.39	1.46	0.33
B4-300-310	54.51	0.53	0.90	55.34	0.55	0.73
C2-60-70	55.69	0.48	1.41	54.79	0.51	1.31
C2-120-130	53.33	1.32	1.09	53.58	1.32	1.12
C7-280-290	55.02	0.35	0.50	56.01	0.40	0.40
D1-400-410	54.43	0.60	1.22	55.43	0.67	0.73
D3-110-120	54.93	0.24	1.09	55.57	0.29	0.55
D4-8-20	55.27	0.24	1.40	55.48	0.28	1.03
D9-150-160	54.68	0.34	2.10	54.92	0.39	1.60
D12-80-90	54.34	0.54	1.43	54.93	0.51	0.92
F3-70-80	54.34	1.10	0.90	55.44	1.17	0.53
G3-9-20	54.43	2.27	1.55	53.33	2.33	1.17
J1-300-310	55.02	0.65	1.34	54.68	0.77	0.73

Tibbetts Paint ($CaCO_3$)

LABORATORY REPORT

DATE: April 3, 1988

TO: John Jones

FROM: Fred Hughes

RE: $CaCO_3$ from Magstone Development

INTRODUCTION: Three samples of calcium carbonate from Magstone Development were obtained.

The grinding time of the three samples were:
Sample 44 - 5 minutes
sample 54 - 10 minutes
sample 65 - 15 minutes

PROCEDURE: These three samples were then each used to produce sample batches of #232 (regular traffic paint). Care was taken that each was prepared the same (ie: order of addition & mixing time).

When these paints were finished their grinds were checked as well as draw downs made. (This was to compare it to one of our batches of #232).

RESULTS: The following table summarizes the results.

	Tibbetts #232	Magstone 44	Magstone 54	Magstone 65
Grind [Haggeman Scale]*	3½	poor approx. 1½	5	3
Colour Comparison	standard	**	0.95	0.99

*The Haggeman grind scale is a measurement of dispersion of the pigment within the paint. It is based on a scale of 1-8 where 1 is a poor dispersion and 8 is a fine dispersion.

**No colour comparison was performed as this paint was found to be too rough and totally unacceptable.

CONCLUSION: From data it could be concluded that the Magstone calcium carbonate could be used in traffic paint but only 54 or 65 size.

Please note that the 54 mess sample performed better than the 65 mess sample. One possible explanation for this is a possible mix up of samples, where 54 was marked 65 and 65 marked 54 by mistake. In either case both were found acceptable with only a slight colour difference.

Fred Hughes

FH/vad

Note - The colour comparison readouts are on a percentage value off the standard sample - #232 in this case. In personal communications with Mr. Hughes, he informed me that 0.99 is still close enough in colour to be acceptable.

APPENDIX 2.

MARBLE MOUNTAIN DRILL CORE LOGS

APPENDIX 2. MARBLE MOUNTAIN DRILL CORE LOGS

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY
DIAMOND DRILL RECORD

Property:	Marble Mountain Quarry	**Bearing:**	030°
Hole Number:	MM-88-1	**Dip:**	45°
Latitude:	45.824566	**Started:**	January 19, 1988
Longitude:	61.041424	**Completed:**	January 26, 1988
Elevation:	54.16 m	**Ultimate Depth:**	92.35 m
Section:	0-40 m	**Proposed Depth:**	91.44 m

Depth in Metres	Formation
0-0.5	Overburden - limestone rubble and fines.
0.5-5.85	Limestone (George River Group). Off white crystalline limestone, medium grained badly broken for 1st metre. Slight mottling throughout of dark grey streaks. At 3.35 m, dyke rock 5 cm dacite.
5.85-7.16	Dyke - dacite, section has small calcite stringers throughout, contact is at 45° angle to core axis, 6 cm. Section of brownish clay at 6.95 m.
7.16-32	Limestone (George River Group). Off white, similar to above, badly broken at 10-10.7 m. Iron staining apparent in this badly broken zone. Serpentinization in areas as well, minor amount of trace pyrite and pyrrhotite in vein filling and along small fracture planes. Colour of stone fluctuates, some sections have no discolouration at all, in others iron staining, serpentine and/or pyrite, pyrrhotite.
32-40	Dolomitic limestone - core is slightly harder and less reactive to acid, similar in appearance to above sections though. Badly broken core at 37.5 for 5 m. Stone is slightly greyer for same section and serpentinization is more prevalent.
40-80.8	Limestone (George River Group). Off white, medium grained crystalline as above. Increasingly better quality stone from 41 m down. No serpentinization, mineralization or staining. 2 bands of bluish limestone 12 cm thick at 47.5 and 47.9 m. Trace mineralization at 51.2 m. Limestone badly broken at 56.7 m for 0.6 m, trace mineralization and discolouration.
80.8-92.35	Limestone (George River Group). Banded limestone black to bluish grey increasing in concentration to end of hole, medium grained, crystalline

Drilling Performed by: Nova Scotia Department of Mines and Energy **Geologist:** Peter Luke

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY
DIAMOND DRILL RECORD

Property:	Marble Mountain Quarry	**Bearing:**	045°
Hole Number:	MM-88-2	**Dip:**	045°
Latitude:	45.824121	**Started:**	January 27, 1988
Longitude:	61.040597	**Completed:**	February 11, 1988
Elevation:	54.07 m	**Ultimate Depth:**	55.78 m
Section:	0-55.78 m	**Proposed Depth:**	91.44 m

Depth in Metres	Formation
0-16.76	Limestone (George River Group). Light grey, medium grained, crystalline limestone. 6 cm of brownish clay at 1.4 m. Limestone is fairly consistent in colour and grade. Bluish-grey banding at 5.5 m for 5 cm. Core is badly broken and weathered at 2.4, 3.6 and 5.2 m. Shear fractures at 45° angle to core axis. Orange-brown tinge beginning at 7 m. 15 cm of brownish clay @ 13.1. Sampling discontinued at 15.24 m due to increasing darkness of stone.
15.25-26.8	Limestone (George River Group). Dark grey-black crystalline limestone, fine grained abundant calcite veins.
26.8-48.46	Limestone (George River Group). Light grey crystalline limestone, medium grained. Slightly better grade than previous light grey section. No alteration or mineralization. Brownish clay, 15 cm at 31.7 m. Abundant calcite filled veinlets 41.5 m.
48.46-55.78	Limestone (George River Group). Dark, banded crystalline limestone, fine- to medium-grained. Sampling discontinued. End of Hole 55.78 m.
	Special Notes: Very little mineralization in MM-88-2, much less than MM-88-1. Core was generally very badly broken and blocky. This attributed to slow drilling. Hole was terminated at 55.78 m because of time constraints and no improvement of rock quality or decreasing blockiness. Samples were quite muddy when crushed which may reflect on brightness figures.

Drilling Performed by: Nova Scotia Department of Mines and Energy **Geologist:** Peter Luke

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY
DIAMOND DRILL RECORD

Property:	Marble Mountain Quarry	**Bearing:**	030°
Hole Number:	MM-88-3	**Dip:**	45°
Latitude:	45.824866	**Started:**	February 15, 1988
Longitude:	61.041212	**Completed:**	February 18, 1988
Elevation:	53.80 m	**Ultimate Depth:**	71.02 m
Section:	0-71 m	**Proposed Depth:**	75 m

Depth in Metres	Formation
0-39.62	Limestone (George River Group). Off white-light grey crystalline limestone, medium grained. Core is badly broken and slightly mottled for 1st 4.6 m. Slightly dolomitic through top of section also. Mottled and darker grey sections at 23.4, 28.6 and 32.9 m. Only trace mineralization of pyrite and pyrrhotite.
39.62-49.68	Limestone (George River Group). Light grey mottled limestone, crystalline, medium grained with darker streaks.
49.68-53	Limestone (George River Group). Grey 'speckled', crystalline limestone, slightly darker than previous section. Mottling appears to be more scattered.
53-71.0	Limestone (George River Group). Banded large scale slightly pinkish in colour throughout a light grey limestone. Still crystalline and medium grained. Sampling discontinued at 39.6 m because of mottled appearance. End of Hole 71.02 m. 43 cm of core stolen at 24.4 and 58.8 m.

Drilling Performed by: Nova Scotia Department of Mines and Energy **Geologist:** Peter Luke

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY
DIAMOND DRILL RECORD

Property:	Marble Mountain Quarry	**Bearing:**	310°
Hole Number:	MM-88-4	**Dip:**	45°
Latitude:	45.824776	**Started:**	February 22, 1988
Longitude:	61.041797	**Completed:**	February 25, 1988
Elevation:	53.45 m	**Ultimate Depth:**	58.52 m
Section:	0-46.6 m	**Proposed Depth:**	60 m

Depth in Metres	Formation
0-3.66	Limestone (George River Group). Grey-black, fine grained, crystalline limestone at 3.66 grades to a banded lighter grey and dark grey limestone.
3.66-15.24	Limestone (George River Group). Banded, crystalline, fine-medium grained limestone. Alternating light grey, dark grey bands, small scale.
15.24-22.86	Limestone (George River Group). Mottled, medium grained, crystalline limestone, lighter grey than above section, grades back into banded limestone.
22.86-28.65	Limestone (George River Group). Banded limestone as in second section grading into grey-black, fine grained, crystalline limestone as in top section.
28.65-35.36	Limestone (George River Group). Light grey, medium grained, crystalline limestone. Some minor vein filling with darker calcite. This section sampled.
35.36-37.19	Limestone (George River Group). Mottled, medium grained, crystalline limestone, light grey to dark grey in colour.
37.19-46.6	Limestone (George River Group). Grey-black, fine, crystalline limestone, same as top of section.
46.6-58.52	Limestone (George River Group). Medium grey, slightly mottled, crystalline limestone to bottom of hole. End of Hole 58.52 m.

Drilling Performed by: Nova Scotia Department of Mines and Energy **Geologist:** Peter Luke

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY
DIAMOND DRILL RECORD

Property:	Marble Mountain Quarry	**Bearing:**	030°
Hole Number:	MM-88-5	**Dip:**	45°
Latitude:	45.823994	**Started:**	February 29, 1988
Longitude:	61.041839	**Completed:**	March 9, 1988
Elevation:	54.44 m	**Ultimate Depth:**	122.8 m
Section:	0-63.1 m	**Proposed Depth:**	122 m

Depth in Metres	Formation
0-2.44	Limestone (George River Group). Dark blue, fine grained, crystalline limestone. Has a large scale mottled appearance.
2.44-32.3	Limestone (George River Group). Medium grey, medium grained, crystalline limestone. Badly broken and weathered in areas.
32.3-32.6	Limestone (George River Group). Dark blue, crystalline limestone. Core angle at 45° to axis.
32.6-33.2	Limestone (George River Group). Medium grey, medium grained, crystalline limestone.
33.2-41.15	Limestone (George River Group). Dark blue, fine grained, crystalline limestone, similar to top section of limestone.
41.15-61.57	Limestone (George River Group). Medium grey, medium grained, crystalline limestone. Not as badly broken and weathered as before. Brownish clay from 43.1 to 43.9 m. 0.3 m dyke rock at 58.2 dacite. Core angle at 45° to core axis.
61.57-63.1	Limestone (George River Group). Mottled, medium grained, crystalline limestone. Grey limestone with blue and flesh mottling, as before.
65.4-105.5	Limestone (George River Group). Mottled to only slightly mottled, crystalline limestone, medium- to fine-grained in some sections, lighter grey. Dolomitic section from 79.25-92.9 m unconsolidated sand at 102.7 m.
105.5-106.6	Possible fault zone-extremely broken core, greenish clay, dark blue limestone clasts and green rock - possibly a dolomite as is too soft to be an intrusive.
106.6-114.3	Limestone (George River Group). Slightly mottled, medium grained limestone. Crystalline and medium- to light-grey.
114.3-122.8	Limestone (George River Group). Light grey, medium grained, crystalline limestone. Best grade of hole MM-88-5. End of Hole 122.8 m.

Drilling Performed by: Nova Scotia Department of Mines and Energy **Geologist:** Peter Luke

NOVA SCOTIA DEPARTMENT OF MINES AND ENERGY
DIAMOND DRILL RECORD

Property:	Marble Mountain Quarry	**Bearing:**	130°
Hole Number:	DDH #2/1965 (relogged)	**Dip:**	050°
Latitude:		**Started:**	March 1965
Longitude:		**Completed:**	March 1965
Elevation:		**Ultimate Depth:**	45.72 m
Section:	0-45.72 m	**Proposed Depth:**	

Depth in Metres	**Formation**
0-38.7	Limestone (George River Group). Off white crystalline limestone, medium grained. Few calcite stringers, minor limonite staining 2 m. Trace mineralization, pyrite, slight mottling (dark grey) at 10-15 m. Core is intact to 32 m then spread throughout core box. Colour, and amount of mineralization and mottling appears to be fairly consistent throughout hole.
38.7-39.3	Dyke olivine diabase-green in colour, calcite stringers are numerous.
39.3-45.72	Limestone (George River Group). Off white, crystalline limestone, medium grained as before. End of Hole 45.72 m.
	Special Notes: DDH2/1965 was resampled and reanalyzed during winter 1988 at the Technical University of Nova Scotia Metallurgical Laboratory. Original logs from this hole could not be located.

Drilling Performed by: Nova Scotia Department of Mines and Energy **Geologist:** Peter Luke

APPENDIX 3.

MARBLE MOUNTAIN CHEMICAL AND BRIGHTNESS ANALYSES

DDH MM-1

Sample Number	Sample Interval m	CaO %	LOI %	Al_2O_3 %	MgO %	SiO_2 %	Fe_2O_3 %	Brightness (Photovolt) 577
MM-1-1	0 - 3.0	53.58	43.20	0.19	1.77	1.12	0.20	82.6
MM-1-2	3.0 - 5.9	54.09	43.31	0.19	0.96	0.59	0.15	95.5
MM-1-3	7.3 - 9.1	54.56	43.62	0.19	0.48	0.57	0.16	94.2
MM-1-4	9.1 - 12.2	52.51	43.49	0.19	0.93	0.59	0.17	92.2
MM-1-5	12.2 - 15.2	51.10	43.78	0.23	2.95	0.76	0.21	91.3
MM-1-6	15.2 - 18.3	53.19	43.43	0.19	1.57	0.65	0.25	92.0
MM-1-7	18.3 - 21.3	51.70	43.45	0.26	2.26	0.78	0.36	90.7
MM-1-8	21.3 - 24.4	53.05	43.75	0.21	2.02	0.50	0.18	94.7
MM-1-9	24.4 - 27.4	48.89	44.14	0.24	4.84	0.76	0.18	94.0
MM-1-10	27.4 - 30.5	42.38	45.10	0.19	10.56	0.76	0.45	90.4
MM-1-11	30.5 - 33.5	43.89	44.60	0.22	10.20	1.02	0.50	88.6
MM-1-12	33.5 - 36.6	51.22	43.67	0.20	3.23	0.71	0.22	87.1
MM-1-13	36.6 - 39.6	51.29	43.76	0.18	3.52	0.70	0.19	92.3
MM-1-14	39.6 - 42.7	54.35	43.05	0.18	0.62	1.21	0.15	95.8
MM-1-15	42.7 - 45.7	53.64	43.10	0.20	0.88	1.16	0.15	94.6
MM-1-16	45.7 - 48.8	52.43	43.22	0.21	1.22	0.73	0.15	95.1
MM-1-17	48.8 - 51.8	54.15	43.31	0.20	0.73	0.66	0.17	92.5
MM-1-18	51.8 - 54.9	54.22	43.38	0.21	0.67	0.55	0.18	91.2
MM-1-19	54.9 - 57.9	54.20	43.54	0.20	0.80	0.63	0.23	93.7
MM-1-20	57.9 - 61	54.15	43.57	0.20	1.23	0.65	0.17	96.5
MM-1-21	61 - 64.3	54.08	43.33	0.25	1.20	0.78	0.28	95.2
MM-1-22	64.3 - 67.1	54.34	43.56	0.22	0.87	0.85	0.25	96.3
MM-1-23	67.1 - 70.1	54.35	43.50	0.16	0.87	0.65	0.25	93.2
MM-1-24	70.1 - 73.2	54.04	43.25	0.29	1.20	0.93	0.29	93.5
MM-1-25	73.2 - 76.2	53.20	43.37	0.29	1.80	0.97	0.32	93.9
MM-1-26	76.2 - 79.2	45.45	44.12	0.30	8.16	1.16	0.43	92.1
MM-1-27	79.2 - 82.3	48.38	44.10	0.25	5.60	0.85	0.35	92.3

DDH MM-2

Sample Number	Sample Interval m	CaO %	LOI %	Al_2O_3 %	MgO %	SiO_2 %	Fe_2O_3 %	Brightness (Photovolt) 577
MM-2-1	0 - 3.0	54.01	43.39	0.19	1.04	0.74	0.24	87.2
MM-2-2	3.0 - 6.1	55.02	42.51	0.21	1.23	0.67	0.19	93.2
MM-2-3	6.1 - 9.1	54.34	43.40	0.19	1.33	0.72	0.23	88.2
MM-2-4	9.1 - 12.2	52.66	43.41	0.21	2.16	0.69	0.25	89.6
MM-2-5	12.2 - 15.2	50.08	43.27	0.30	5.43	0.97	0.35	87.3
MM-2-6	27.4 - 30.5	46.10	43.30	0.21	7.61	0.69	0.42	88.7
MM-2-7	30.5 - 33.5	53.33	42.71	0.15	2.50	0.80	0.24	92.7
MM-2-8	33.5 - 36.6	54.17	42.03	0.16	1.40	0.75	0.23	92.3
MM-2-9	36.6 - 39.6	54.93	42.04	0.30	1.67	1.06	0.29	90.9
MM-2-10	39.6 - 42.1	53.33	42.44	0.26	1.53	1.36	0.50	81.9
MM-2-11	43.9 - 45.7	55.01	42.45	0.30	0.94	0.81	0.32	91.5
MM-2-12*	45.7 - 48.5	54.17	42.86	0.25	1.35	0.82	0.29	92.7

* MM-2-12 had some of sample MM-3-12 mixed with it.

DDH MM-3

Sample Number	Sample Interval m	CaO %	LOI %	Al_2O_3 %	MgO %	SiO_2 %	Fe_2O_3 %	Brightness (Photovolt) 577
MM-3-1	0 - 3.0	50.39	43.71	0.19	5.14	0.61	0.35	89.1
MM-3-2	3.0 - 6.1	48.12	43.87	0.15	6.16	0.60	0.40	91.0
MM-3-3	6.1 - 9.1	51.48	43.27	0.13	3.60	0.52	0.28	91.6
MM-3-4	9.1 - 12.2	53.08	42.86	0.13	1.77	0.78	0.27	90.7
MM-3-5	12.2 - 15.2	53.75	43.23	0.14	1.31	0.59	0.28	91.9
MM-3-6	15.2 - 18.3	54.51	42.80	0.14	0.69	0.47	0.31	93.5
MM-3-7	18.3 - 21.3	54.51	42.39	0.14	0.75	0.80	0.28	92.9
MM-3-8	21.3 - 24.4	54.68	42.67	0.14	0.73	0.85	0.25	91.8
MM-3-9	24.4 - 27.4	52.66	43.15	0.16	3.06	0.67	0.23	92.4
MM-3-10	27.4 - 30.5	54.85	43.49	0.13	0.63	0.67	0.27	91.1
MM-3-11	30.5 - 33.5	54.51	42.51	0.16	0.93	0.87	0.40	91.1
MM-3-12	33.5 - 36.6	48.03	43.29	0.20	6.31	1.10	0.44	90.0
MM-3-13	36.6 - 39.6	50.64	43.18	0.18	5.52	0.78	0.42	88.8

DDH MM-4

Sample Number	Sample Interval m	CaO %	LOI %	Al_2O_3 %	MgO %	SiO_2 %	Fe_2O_3 %	Brightness (Photovolt) 577
MM-4-1	28.7 - 31.7	55.27	42.70	0.15	0.65	0.80	0.31	90.7
MM-4-2	31.7 - 33.5	54.59	43.19	0.17	0.54	0.93	0.34	89.1
MM-4-3	33.5 - 35.4	54.59	42.97	0.21	1.11	0.70	0.17	92.4

DDH MM-5

Sample Number	Sample Interval m	CaO %	LOI %	Al_2O_3 %	MgO %	SiO_2 %	Fe_2O_3 %	Brightness (Photovolt) 577
MM-5-1	12.2 - 15.2	54.51	42.80	0.33	1.19	1.28	0.18	85.0
MM-5-2	15.2 - 18.3	54.50	42.08	0.47	0.69	1.38	0.21	82.6
MM-5-3	18.3 - 21.3	53.00	42.71	0.41	0.50	1.48	0.20	83.4
MM-5-4	21.3 - 24.4	54.76	42.75	0.53	0.47	1.33	0.24	84.3
MM-5-5	24.4 - 27.4	54.59	42.52	0.53	0.47	1.50	0.32	86.6
MM-5-6	27.4 - 30.5	54.85	42.41	0.56	0.67	1.60	0.25	82.3
MM-5-7	30.5 - 32.3	54.09	42.17	0.59	0.57	1.96	0.23	88.4
MM-5-8	42.7 - 45.7	52.99	42.69	0.41	2.48	1.43	0.25	88.0
MM-5-9	45.7 - 48.8	54.59	42.19	0.52	1.01	2.11	0.23	86.9
MM-5-10	48.8 - 51.8	53.50	41.70	0.80	0.46	2.88	0.18	89.2
MM-5-11	51.8 - 54.9	52.07	41.38	1.06	2.17	2.91	0.33	83.5
MM-5-12	54.9 - 57.9	51.99	41.06	1.05	2.07	3.02	0.34	85.4
MM-5-13	57.9 - 61	52.07	41.85	0.64	3.16	2.42	0.33	85.8
MM-5-14	61 - 64.3	53.67	42.68	0.47	1.57	1.55	0.22	88.7
MM-5-15	66.8 - 69.5	54.68	42.07	0.56	0.83	1.84	0.18	91.1
MM-5-16	69.5 - 72.5	54.76	43.24	0.19	1.26	0.77	0.17	92.4
MM-5-17	72.5 - 75.6	54.26	42.68	0.26	1.54	0.82	0.19	91.5
MM-5-18	75.6 - 78.6	48.79	42.97	0.39	5.44	1.55	0.30	88.8
MM-5-19	79.2 - 82.3	47.78	43.92	0.15	7.23	0.78	0.28	91.4
MM-5-20	82.3 - 85.3	44.41	44.46	0.16	9.19	0.66	0.31	89.3
MM-5-21	85.3 - 88.4	39.17	44.92	0.20	12.07	0.90	0.46	83.2
MM-5-22	88.4 - 91.4	46.94	44.10	0.22	8.55	0.77	0.34	92.3
MM-5-23	91.4 - 94.5	49.63	43.71	0.24	5.91	0.87	0.29	91.6
MM-5-24	94.5 - 97.5	54.01	43.05	0.18	1.77	0.63	0.18	94.9
MM-5-25	97.5 - 100.6	54.17	43.07	0.15	1.62	0.47	0.17	92.8
MM-5-26	100.6 - 103.6	54.17	42.99	0.169	1.67	0.91	0.16	89.3
MM-5-27	103.6 - 105.5	54.01	42.65	0.19	1.29	1.24	0.19	93.0
MM-5-28	106.7 - 109.7	54.85	42.29	0.14	0.63	1.15	0.21	92.8
MM-5-29	109.7 - 112.8	54.93	42.71	0.17	0.81	0.62	0.13	93.3
MM-5-30	112.8 - 115.8	54.85	42.85	0.15	0.81	0.66	0.11	93.6
MM-5-31	115.8 - 118.8	54.76	42.80	0.18	0.91	0.73	0.12	94.2
MM-5-32	118.9 - 121.9	54.76	42.80	0.19	1.06	0.81	0.11	93.0

DDH 2/65

Sample Number	Sample Interval m	CaO %	LOI %	Al_2O_3 %	MgO %	SiO_2 %	Fe_2O_3 %	Brightness (Photovolt) 577
DDH-2/65-1	0 - 3.0	49.29	44.18	0.22	5.24	0.80	0.22	88.4
DDH-2/65-2	3.0 - 6.1	46.43	44.58	0.25	7.39	0.87	0.24	93.1
DDH-2/65-3	6.1 - 9.1	45.93	44.29	0.27	7.68	0.87	0.29	90.4
DDH-2/65-4	9.1 - 12.2	48.12	44.04	0.27	5.62	.73	0.20	89.7
DDH-2/65-5	12.2 - 15.2	50.81	43.78	0.36	3.65	0.75	0.19	90.5
DDH-2/65-6	15.2 - 17.1	52.15	43.59	0.27	2.45	0.87	0.19	92.7
DDH-2/65-7	21.3 - 24.4	54.85	43.04	0.27	0.58	0.84	0.11	93.8
DDH-2/65-8	24.4 - 27.4	55.01	43.23	0.24	0.70	1.02	0.10	93.0
DDH-2/65-9	27.4 - 30.5	54.01	43.26	0.42	1.00	0.95	0.10	93.2
DDH-2/65-10	30.5 - 33.5	54.01	43.83	0.33	1.09	0.71	0.14	93.3
DDH-2/65-11	33.5 - 36.6	50.14	43.81	0.60	3.83	1.46	0.22	87.4
DDH-2/65-12	36.6 - 39.6	52.32	43.71	0.42	2.44	1.13	0.16	92.5
DDH-2/65-13	39.6 - 44.2	53.84	43.50	0.36	1.49	0.88	0.13	93.8
DDH-2/65-14	44.2 - 45.7	55.01	43.77	0.23	0.61	0.74	0.09	96.1